DOCUMENT RESUME

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ABSTRACT

This publication is the result of a project to develop microbiology instructional materials for vocational college students. These materials are a series of self-paced modules. Each module includes a pre-test, an introduction and historical packet, an organizational packet to set the framework for in-depth study, one or more in-depth packets, a challenge packet in which the student moves into the environment, and an end-of-module test. There are 10 theoretical modules which cover the basics needed in microbiological studies and 20 environmental modules which actually are the microbiological studies. These modules may be adapted, modified and applied in a variety of ways. The final report of the project is presented which includes a literature review, methodology description, summary, conclusions and recommendations, budget, and bibliography sections. The materials were used by a total of 60 students who were either natural resource management seniors or freshmen, registered nurses, licensed practical nurses, or laboratory technicians in non-credit or night courses. (MR)

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ENVIRONMENTAL MICROBIOLOGY MODULES

FINAL REPORT

JUNE 30, 1977

SE 023 477

NEW HAMPSHIRE VOCATIONAL TECHNICAL COLLEGE
Milan Road, Berlin, New Hampshire 03570

TITLE OF PROPOSAL	ENVIRONMENTAL MICROBIOLOGY MODULES
APPLICANT ORGANIZATION	New Hampshire Vocational Technical College
INITIATOR/DEVELOPER	Raymond Walke Raymond H. Walke, Ph. D. Professor Natural Resources Management
SPONSOR	Edward C. Oleson Edward C. Oleson Director NHVTC-Berlin
DURATION OF ACTIVITY	July 1, 1975 - June 30, 1977
FEDERAL FUNDS EXPENDED	$15,206.27

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ABSTRACT

TITLE OF PROPOSAL:	Microbiology Modules
PROGRAM INITIATOR:	Raymond H. Walke, Ph.D.
WRITERS:	Raymond H. Walke, Ph.D. Jayne G. Walke
APPLICANT ORGANIZATION:	New Hampshire Vocational Technical College-Berlin
TOTAL FUNDS USED:	$15,206.27
BEGINNING/ENDING DATES:	July 1, 1975 to June 30, 1977

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OBJECTIVES

To provide two sets of modularized units, the first, a set of ten theoretical units covering the background necessary for microbiology; and the second, a set of twenty environmental microbiology units.

The first set of modules develops the historical background of science, basic concepts of chemistry, biochemistry, taxonomy, and laboratory techniques.

The second set of modules includes units on bacteria, viruses, nematodes, slime molds, fungi, lichens, actinomycetes, liverworts, mosses, algae, ferns, parasitology, protozoans, and the ecology of these organisms.

PROCEDURES

Textbooks, manuals, supplemental technical literature excerpts, standard references, and library reading materials are brought together in each module. Slides, filmstrips and casettes augment carefully chosen detailed explanations. From field samples using hand lens and, when necessary, the light microscope; observations, test results, drawings, and samples are organized into a field identification notebook which has sections devoted to plants, animals, minerals, rocks, soils, and MICROBES. A section is also kept on TECHNIQUES. The field notebook is used in other classes but is an integral part of ENVIRONMENTAL MICROBIOLOGY. All *references utilized or introduced as historically or professionally important are keyed into a DATA STORAGE & INFORMATION RETRIEVAL SYSTEM so that learning is an on-going and cumulative process which continues over a two-year period. Self-tests and appraisals are used when the student studies packets which are within a module, but END-OF-MODULE tests determine the student grade and whether "recycling and restudy' is necessary. The modules are designed to develop confidence and competence, and may be used at a slow speed if necessary. The student, individually, sets the pace.*

RESULT:

The use of these modularized units will allow for:

1. Variability in societal, parental, and student expectations concerning the subject matter and behaviors to be learned.

2. Variability in interactions among students, between students and teachers, and between students and materials.

3. Variability of subject matter in forms (either concrete or abstract) and in format (as with books, objects, films, and materials) that most efficiently and effectively support the behaviors sought.

4. Variability in an instructional setting (individually or group) in which interactions can take place, subject matter can be learned, and behaviors can be practiced.

5. Variability in motivation. Students may have little or no motivation toward science or education itself.

6. Variability in time slot available to the student. Modular units can be used at any time of day in school or at home, if the unit is mobile. This mobility makes the unit available to the evening division, to working students, to outside industry or other groups.

7. Variability in rate and direction of changes in technology. The modules can easily be updated and expanded to comply with the demands of our ever-changing world.

8. Variability in physical location. The modules are mobile and can easily be moved to other areas in the school or to remote locations.

9. Variability in audio-visual technology. The modules can be modified for display on TV, in filmstrips, or to film-cassettes made with little effort at reasonable cost.

10. Variability in instructors, institution and time-space requirements. As cost increases, space available decreases, and the entrance requirements in schools become less stringent than has heretofore been known, the concerned teacher must utilize the modular approach to give the INDIVIDUAL the attention so necessary for success. Relieved of most of the irksome tasks of teaching, the instructor can provide personal attention to the student which cannot be provided under the conventional system.

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Sub-Section I: INTRODUCTION:

RATIONALE:

Several years ago instructors in environmental science, nursing and culinary arts determined that students were ill-prepared in areas microbiological. Unfortunately, neither students, instructors, nor the facility were ready to teach adequately this technical area. To allow students in Natural Resources, Nursing, and Food Service to complete their programs with shallow background in microbiology appeared to be educationally unsound. A grant was written originally to include the three curricula mentioned, but for lack of funds only the Natural Resources microbiological area was funded. This study is the result of two years of development.

PROBLEM:

One problem was immediately obvious: the very word 'MICROBIOLOGY' struck terror into the hearts of vocational-technical students. Their backgrounds in science and mathematics were generally poor; they had suffered humiliation and failures in previous school experiences. If ENVIRONMENTAL MICROBIOLOGY were to be taught then something radically new in teaching methodology had to be used.

OBJECTIVES:

The OBJECTIVE of this project was to produce a program in ENVIRONMENTAL MICROBIOLOGY which could be modularized, that is, broken into palatable self-contained units; could be mastery-oriented; and which could be within the grasp of the two-year vocational-technical college student.

Specifically thirty (30) modules were constructed, ten (10) in basic areas, and twenty (20) in areas microbiological in nature.

THEORETICAL MODULES:

TM-1	*ATOMIC THEORY*
TM-2	*THE PERIODIC TABLE*
TM-3	*SOLUTION CHEMISTRY*
TM-4	*CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA*
TM-5	*TAXONOMY*
TM-6	*BASIC LABORATORY TECHNIQUES*
TM-7	*CHEMICAL BONDING*
TM-8	*ORGANIC CHEMISTRY*
TM-9	*ACID-BASE, REDOX, & ELECTROCHEMISTRY*
TM-10	*CELL CHEMISTRY AND STRUCTURE*

ENVIRONMENTAL MICROBIOLOGY MODULES

EM-1	BACTERIAL ECOBIOLOGY
EM-2	VIRUSES
EM-3	NEMATODES
EM-4	PLANT PATHOLOGY
EM-5	WATER AND WASTEWATER MICROBIOLOGY
EM-6	BACTERIA
EM-7	MICROBIOLOGICAL METHODS
EM-8	SLIME MOLDS
EM-9	FUNGI
EM-10	LICHENS
EM-11	ACTINOMYCETES
EM-12	FERNS AND FERN ALLIES
EM-13	LIVERWORTS
EM-14	MOSSES
EM-15	ALGAE
EM-16	PARASITIOLOGY
EM-17	AQUATIC MICROBIOLOGY
EM-18	SOIL MICROBIOLOGY
EM-19	PROTOZOANS
EM-20	ADVANCED ANALYTICAL TECHNIQUES

ASSUMPTIONS:

It was ASSUMED that students would enjoy self-paced study, as a chance to work within an area of microbiology with some freedom in an open-laboratory, with minimal supervision, and especially would appreciate being allowed the time to achieve mastery knowledge over some very difficult but interesting areas of study. It was further assumed that allowing a student to essentially determine his or her own grade would be a welcome change over past experiences. Within the college routine it was assumed that time schedules for open-minded modularized classes and courses could be worked out and that space, time, materials, and other logistic problems would be minimal.

In all of these assumptions the initiator erred. The acceptance of mastery-oriented, student-paced, modularized educational routines within a traditional college produced considerable irritation amongst students, faculty, administration, and even among faculty within the projected domain. Finding space for an open laboratory; finding faculty who would man the evening open-laboratory; finding the funds to service the program adequately; and finding TIME were problems which plagued the project from its very inception.

METHOD:

The project can be broken down into phases:

1. Bibliographic search and planning
2. Production of initial trial modules
3. Utilization and feed-back period
4. Revision and consolidation phase
5. Preparation of finished modules

Originally fifteen (15) theoretical modules (TM's) were envisioned. During the project this was reduced to ten (10).

The twenty (20) environmental modules (EM's) were produced, although changed in content during the revision phase.

TERMS ENCOUNTERED:

MODULE = A self-contained essentially packaged unit on one well defined subject which itself is composed of PACKETS.

PACKET = A sub-unit of the module. A packet contains the materials needed for a student to learn a well-defined portion of the modular unit. Packet's are usually made up of: 1) a filmstrip, cassette, and/or reading unit; 2) a programmed review; and 3) a self-quiz.

END OF MODULE TEST = A test which is only taken after the packets within the module are completed to a mastery level acceptable to both student and instructor. It is usually a direct answer test made up of multiple-choice, true-false, or matching questions, but it may include an essay or drawing.

FIELD IDENTIFICATION NOTEBOOK (KRITTER NOTEBOOK) = A notebook kept by the student which includes a page for each animal, vegetable or mineral encountered during the two years spent in the NATURAL RESOURCE MANAGEMENT CURRICULA. Use of the notebook is integrated into the module program.

DATA STORAGE DECK = A bibliographical and practical retrieval system using notched cards and pin retrieval. References, historical articles, techniques, technical terms, and laboratory work are keyed to this system.

DIAGNOSTIC TEST = A test designed to ascertain whether a student could by-pass with credit a module without having to complete each packet or to ascertain which packets within a module could be checked off as completed satisfactorily.

CONTINUING GRADE = A method of grading students in which grades reported each term or semester are accumulated and correctable. Open-ended courses are not given final grades until both student and instructor accept the competence level as adequate.

TM = A module of theoretical nature concerned with the development of the background necessary for success in the more advanced and specialized EM's.

EM = A module concerned with a specific well-defined portion of ENVIRONMENTAL MICROBIOLOGY, e.g., Nematodes, Actinomycetes, or Slime Molds.

KRITTER = A nonsense term invented by the students and incorporated into the modules which describes a subject animal, vegetable, tree, shrub, mineral, rock, or MICROBE to be studied and placed in the field identification notebook.

Sub-section II: REVIEW OF LITERATURE

As has been noted by numerous educators traditional courses utilizing textbooks, blackboards, homework and tests are not, and cannot, provide quality education to students of a vocational college who do not have the educational background nor intellectual attitude to cope with two more years of what appears to be "MORE HIGH SCHOOL".

Faced with the demands of a highly competitive world requiring that students be skilled, poised, and confident; a dwindling supply of qualified students; and an appalling lack of funding, what can an instructor do?

In his review of instructional media research, Allen (1971) concluded that a combination of pre-testing, (Tosti, 1972), multi-media modularization, tutoring, and examination could upgrade teaching by allowing for individual differences (Thorndike, 1911 - Torkelson, 1972 - Lipson, 1968 - Savage, 1974) while relieving the teacher of many of the traditional drill sessions so that his instructor could be a counselor and guide, rather than a taskmaster (Gustafson, 1972). Leaders in the use and promotion of innovation in education are Postlewait (1969) and Lange (1972). They found, as is the intent in this project, that most traditional courses could be converted smoothly into modularized courses. Doyt (1974) studied personalized laboratory instruction in microbiology were woefully ill-trained in laboratory skills. The resultant lack of confidence and understanding was reflected in the drop-out rate and in low knowledge carry-over into related fields of endeavor.

Fenner (1970), Romey and Dean (1971), and Gould (1972) found that in earth sciences the use of mini-courses and audio-tutorial materials dramatically improved not only factual retention but the attitude of students toward the more conceptually difficult area of geology, soil science, and environmental studies.

RELATED RESEARCH

As early as the first century, Quintilian utilized the audio-tutorial system. In the Roman schools of the time the orators, Isocrates and Quintilian, were concerned with Sophist "arete", or excellence, and could be called the technical educators of the time. In the 1800's, Dr. Bell in India revitalized the tutorial system of teaching and developed what is now known as the Madras system (Thiagarajan, 1973). In our country, Washburne (1925) suggested at the NSSE Conference in Chicago that we adapt the schools to individual differences. Ferster and Perrot (1968) further utilized simple modules, tutorials, and another useful and practical innovation - peer testing. Keller (1968) carried this concept to include student proctor scoring. His essay entitled "Good-bye Teacher" candidly considered what many teachers and administrators (Thorndike, 1911) fear about individualized modular courses - that the teacher loses quality control over education. Hustuft (1973) attempted to clarify the role of innovative teaching in our changing educational scene. He differentiates between adjunctive roles for media such as for illustration, exemplification, motivation, or clarification and the direct instructional role. Drumheller discusses the possible pitfalls of individualized teachers in the "Confessions of a Module Writer", (Drumheller, 1973).

The units produced for this program will serve as adjuncts to some courses and as total instructional units in others. The audio-visual section of each module will help to overcome language problems as found by LeBean (1975) in his work with microbiological modules.

Since instructional modules utilize a minimum of space, little teacher time, and are not on schedule for space-time units, materials not generally offered in the college can now be made available. Rich (1972) found that nearly every foreign language could be offered to students inexpensively for as few as two students. The UNIPAC system developed by Field and Swenson (1972) makes possible both form and process for actually individualizing units of instruction. Similarly, Flanagan (1972) developed his PLAN system of modularizing.

To augment A-V media, programmed reading material was developed by Hanna (1971) and Dalton (1972); and test pool information by Harke (1971) and Denny (1973).

Palmer (1973) in his provocative article on programmed learning, showed that the tutor is an important requirement to success with such impersonal drill. In his search for a better way to teach earth science, Qutub (1971) discussed the didactic lecture-oriented approach which featured ever-increasing class size, devastating student recitation, crowded confused laboratory 'experiments', memorization and boredom. To this classical unhappy scene, he compared the self-directed approach (Kapfer, 1972) which had none of the above characteristics and which could appeal to all rather than just a captive interested few.

At R.P.I., Rainey (1974) found that complex areas of electrical engineering technology which accounted for many drop-outs, could be much better covered using modular units and self-directed study, testing and evaluation.

In teaching vocational agriculture, Richardson (1974) found that performance based instruction using the multi-media system allowed their department to better train more students at less expense. Russell and Biggor (1974) found that teacher efficiency, equipment control, higher staff-tutor-student involvement and an all around improvement in the educational environment resulted from the use of modules.

Science courses are often suggested for non-science majors and here the studies by Reif (1969) and Klopfer (1971), have shown that mini courses are ideally suited for them. Romey and Dean (1971) found that such mini courses made flexibility possible when working with large introductory science courses.

In working with adult education and the development of retraining courses, the use of Learning Activity Packages (LAP) as described by Smith (1972) has proven valuable. Similar to microbiology in complexity and more difficult conceptually, is the field of genetics. Waananen (1974) pioneered in the production of mastery units which removed the course from the 'most feared' list and fostered a doubling enrollment. In the report to the Commissioner of Education, New York, Tickton (1970) emphasized the need to reach those out of school through increased use of multi-media modules.

Tornyary (1972) challenged nursing instructors to be aware of the training needs of those who had already graduated. She saw in the utilization of learning packets a means by which self-directed improvement and responsibility, being learned behavior, could be taught. Meers (1975) describes the need to develop operator and engineer mini courses for those involved in water and waste-water pollution control. As schools face the rapid changes in technology, the more visionary educators (Glaser, 1974) see the need for mini courses to be developed. In a message to the American Society for Microbiology, Young (1975) saw that the role of nurses will change and include microbiological skills. Our present programs have difficulty in meeting the challenge of change. Meierhernry (1966) in his thoughtful article on innovation, education, and media, could find no financially sound direction for educators to move other than toward individualization through judicious use of multi-media. Support for individualized instruction also comes from the American Nurses Association (ANA, 1974). Their studies indicate that as more functions are transferred from physician to nurse, that courses using multi-media which are nurse-problem orientated will supply the needed modernization. Emanuel (1974) in aligning priorities for agricultural educational research, gave the highest priority to the multi-media approach. Savage (1974), writing for the NIE about work emanating from the Wisconsin Research and Development Center for Cognitive Learning, similarly called for acceleration of individually guided educational development.

Educational research in the areas of microbiology, nursing, food science, geology, chemistry, languages and mathematics shows that modularization of large sections of the curricula in colleges can improve education, save money, and meet the needs of a large diverse population.

Sub-Section III: METHODOLOGY

DESIGN:

Each module was designed to have:

1. A DIAGNOSTIC TEST as a pre-test.

2. An introduction and historical packet.

3. A taxonomic or organizational packet to set a framework for an in-depth study.

4. One or more in-depth packets utilizing texts or articles and programmed reviews.

5. A practical 'hands-on' packet with which the student performs tasks and produces tangible results.

6. A 'challenge' packet in which the student moves out into the local natural environment, finds a problem, and then solves that problem utilizing the skills he/she has mastered previously.

7. An END-OF-MODULE TEST used to produce the grade or to emphasize what the student must study before taking a retest.

This project is unique in that as each packet is completed the student completes a self-quiz and analysis before moving on. The student is able to 'zero-in' on specific problem areas so that the instructor may spend time on those points not understood without wasting time on material already understood by the student.

The project did involve students who were young and old; male and female; science-oriented and science-oblivious. The use of project materials all through the process of writing these modules aided in controlling difficulty and routing out prejudice.

POPULATION:

Four distinct groups of students employed the project materials during its developmental stages.

1. RN's and LPN's in an open-ended non credit clinical microbiology course utilized portions of the chemistry, biochemistry, bacteriology modules. (10)

2. Senior Natural Resource Management students utilized sections of chemistry, microbiology and especially the ecological modules. (10)

3. Freshmen Natural Resource Management students utilized the chemistry, microbiological, nematode, and soil microbiology modules and will continue to complete the required nine modules next year. (30)

4. RN's and Laboratory Technicians utilized portions of the modules in a night class in Public Health Microbiology. (10)

TOTAL STUDENTS INVOLVED: 60

TIME SCHEDULE:

Early in the production of these modules it became obvious that the projected time schedule could not be maintained. The initiator was forced to work at home or at the local library because funds were slow to arrive and he had to work many days elsewhere to maintain his own financial solvency. During the school years the burden of an expanding and innovative departmental program made it impossible for the initiator to work upon the project during the day since office and laboratory conditions were crowded. Materials necessary for review and augmentation were slow to arrive and work on modules proceeded in bits and pieces. . .no module being truly complete until the Summer of 1976.

It must be emphasized that the original budget was suspected to be inadequate and that the initiator was overly optimistic concerning just what could be accomplished by a married couple beyond the normal working day. Work proceeded almost every night that the college was open, on weekends at home, during the evenings during Coast Guard Reserve Training, on holidays, and beyond the limit of the grant funding into 1977. The production of thirty (30) in-depth innovative modules of the caliber envisioned could barely be produced within the budget allowed. Given adequate funds, work space, and sufficient time a more polished presentation would have been possible.

It is hoped that those educators considering modularizing will recognize that those involved need to be relieved of other duties and given adequate time and space to work if better results than these are to be expected. Modularization does not save money, space, or time, but it does produce good educational results and a better educational experience for the students involved.

Sub-Section IV: FINDINGS

STUDENT ACCEPTANCE OF MODULARIZED COURSE:

Perhaps the most disturbing factor discovered during the use of the modularized units in microbiology concerned student dislike for MASTERY. Students having sampled twelve years of traditional education expected to study a unit, take a test, and finish with a quiz, but they did not expect to be required, or worse yet, allowed, to decide whether they should repeat a unit to gain MASTERY.

Closely related to student dislike for mastery is their difficulty with programmed reviews. Students require inordinate amounts of time and coaching before they can utilize programmed material without cheating themselves. They rush through reading assignments and the reviews in order to take the self-quiz. They often cheat themselves on self-quizzes, assume they know more than they do and rush ahead to fail the end-of-module test.

Experience indicates that a thorough introduction, orientation, and indoctrination in the why, how, where, and when of programmed, self-monitored, self-paced learning is absolutely essential. Once the student recognizes that he can learn more, obtain higher grades, and ultimately spend less tuition money...then the program works.

FACULTY ACCEPTANCE OF MODULARIZED COURSE:

Faculty outside and even inside the department found it difficult to understand that students in the NRM department worked odd-hours, at uneven rates, on multiple projects, in the same place and time. The laboratory was likened to a "Chinese Classroom" where students talked, dissected, stained, cooked, sterilized, poured, wrote, and read -- often in apparent chaos. Faculty members who were unaware of the time span or that the course was open-ended could not see how the assigned work could be completed in a semester. Of course much of the work could be completed within a reasonable time frame if the student made use of laboratory time, judiciously. Faculty, within the department, were reluctant to spend the necessary time to develop their own individualized courses, and to spend the time necessary with the students for individualized instruction.

ADMINISTRATION ACCEPTANCE OF MODULARIZED COURSES:

The introduction of modularized, open-ended, continuously graded courses into a college and regimen accustomed to the traditional course-by-course approach produced several problems. Difficulties with the Veteran's Administration and other student tuition funding organizations in translating continuing grading into a form acceptable to their criteria were developed, but not without considerable debacle. Any college attempting to move toward utilization of modular education and continuing grading will have difficulty with the Veteran's Administration.

LOGISTICS AND MODULARIZED COURSES:

When a course or program evolves from traditional to innovative, the problems of time, space, materials and staff grow with it. Modularization and individualization of subject matter require phenomenal effort on the part of school administrators, involved faculty and financial officers. To set up a program of this nature required more time of the initiator than was available; more space in the laboratory and office than was anticipated; more time out of a crowded student schedule; and more demands on service and support personnel. It should not be a surprise that to work with students who have weak backgrounds in a college where space and funds are barely adequate will require that the day be lengthened for all involved. It is to the credit of NHVTC-Berlin that the sacrifices were made, which made possible success.

STUDENT RESULTS:

This year, students of the Natural Resource Management Program were subjected to most of the modules prepared or exposed to those other modules still only roughed out. The object was not to produce micro-biologists, but to expose NRM students to the concepts, resources, techniques, taxonomy and future expectations of scientists working with myxomycetes, actinomycetes, protozoans, nematodes, eubacteria, fungi, algae, metaxoans, and metaphyta; and to the interrelationships between the microbiological fields and the fields of soils, forestry, chemistry, biochemistry, geology, ecology, and taxonomy. Despite the difficulties involved in the two years of struggle the students have gained a great deal; the NRM faculty has learned more; and the program is much enriched and now is very viable.

Sub-Section V: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Two sets of modules were produced by this project: the first, a set of ten modules developed the basic concepts required of those who would undertake the Study of Environmental Microbiology; and the second, a set of twenty modules, addressed each major area of Environmental Microbiology considering essentially the realm of the microbiologist to be the fields which required for in-depth study - a microscope.

Each module contains an introduction to the subject area, a pre-test for diagnostic purposes, two signout sheets for record keeping, a number of packets which involve reading, programmed review, slide-cassette displays, and kits to develop skills, and an END-OF-MODULE TEST.

The modules were developed and simultaneously utilized at NHVTC-Berlin beginning in the winter of 1976 and extending until the Spring of 1977 on forty two-year students, with generally poor science-math backgrounds and twenty adult night students, with the same poor science backgrounds.

It was found that students, faculty, administration, and financial officers should be made fully aware that adjustments in space, time, allotments, materials budgeting, grading, and even school philosophies may -- and probably will -- be decidedly affected by incorporation of modularized, self-paced, open ended, mastery oriented, innovative programs into a pre-existing program. At NHVTC-Berlin the development and adjustment phases are over and the results will become apparent when students graduate who are competent and confident in their know-how.

CONCLUSION:

It may be concluded that using the programs outlined in this report, that sincere, motivated, disciplined students can, and do, cope with the complex and demanding areas within ENVIRONMENTAL MICROBIOLOGY and that those students with less interest can benefit and develop competency in some areas of this field. Better teaching is possible using the methods advocated by this report, but overall cost remains high and instructors who undertake this system must expect to heighten their own awareness of all aspects of microbiology and to become involved in close relationships with students and student learning processes.

RECOMMENDATIONS:

Work cannot stop with the production of these modules. They will require constant revision to upgrade them; new quizzes, tests, readings, and photographs must be produced. The thirty modules are a framework within which the instructor can develop for students a bulwark of in-depth knowledge.

FINAL REPORT BUDGET

As of June 30, 1976

TITLE OF PROPOSAL: Microbiology Modules

DIRECTOR: Dr. Raymond Walke

INSTITUTION OR AGENCY: New Hampshire Vocational Technical College, Berlin, N. H.

BEGINNING DATE: July 1, 1975 ENDING DATE: June 30, 1976

GRANT AMOUNT: $ 12,300.00 RECEIVED TO DATE: $ 12,298.90

I. DIRECT COST			
A. Director: Dr. Walke - 546.8 Hours @ 5.4775/Hr.		$2,995.29	
B. Employee Benefits - Social Security		222.86	
C. Travel - Trips from Berlin to Boston and Durham for research, July 2,1975 to November 17, 1975	$265.92		
- Trips to Concord for meeting and to Durham for research, Dec. 15, 1975 to Jan. 10, 1976	58.80		
		324.72	
D. Supplies and Materials Actually Used in Project (See Appendix B)		6,655.00	
E. Communications		82.13	
F. Services - Provided by NHVTC-Berlin (See Appendix A)			
G. Final Report Cost - Provided by NHVTC-Berlin (See Appendix A)			
H. Equipment		2,018.90	
Subtotal - Direct Cost			$12,298.90
II. INDIRECT COST			- 0 -
III. TOTAL COST			$12,298.90
IV. COST SHARING (See Appendix A)			$12,356.31

APPENDIX A

(COST SHARING)

1975/76

I.	TIME - COSTS		
	- Administration - Director, Deans	$ 500.00	
	- Secretarial Assistance	250.00	
	- Accounts - Purchasing	500.00	
	- Concord Agencies (Cost Sharing)	100.00	
	- Custodial - Book Store	200.00	
			$ 1,550.00
II.	CURRENT EXPENSES		
	- Administrative	250.00	
	- Supplies	1,500.00	
	- Heat, Light, Power	200.00	
	- Postage	50.00	
	- Telephone	100.00	
			2,100.00
III.	EQUIPMENT (Estimated)		8,000.00
IV.	TRAVEL		150.00
V.	FINAL REPORT COSTS (1975/76 Cost Sharing)		
	- Paper	100.00	
	- Covers	50.00	
	- Mimeographing (Stencils)	50.00	
	- Typing (3 Weeks @ $118.77 per week)	356.31	
			556.31
	TOTAL		$12,356.31

APPENDIX B

(MATERIALS & SUPPLIES)

1975/76

Materials and Supplies Actually Used in Project

1	Book "From Vital Force to Structural Formulas"	$ 4.50
1	Book "Biochemistry of Green Plants"	14.28
1	Book "Organic Chemistry of Biological Compounds"	
1	Book "Intro. to Bacteria and their Ecobiology"	10.15
1	Book "Biology of Protozoa"	13.57
1	Book "Manual of Soil Fungi"	10.85
1	Book "Actinomycetes"	14.23
1	Book "Abstracts of Microbiological Methods"	52.22
1	Book "Bergey's Manuals of Bacteriology"	45.00
1	Book "Methods of Microbiology"	13.03
1	Book "AOSA Rules for Testing Seeds"	4.50
1	Book "Tetrazolium Testing Handbook for Agricultural Seed"	3.00
1	Book "Cells: Structure and Function"	3.95
1	Book "Inquiry into Life"	3.95
1	Book "Microbiological Applications Complete"	8.95
1	Book "Fleshy Fungi"	6.25
1	Book "Tapeworms"	5.00
1	Book "Trematodes"	5.50
1	Book "Lichens"	4.50
1	Book "Protozoa"	6.00
1	Book "Laboratory Tests"	4.70
2	Books "Biology of Lichens"	35.90
1	Book "Biology of Protozoa"	26.64
1	Book "Biology of Fungi"	9.00

1	Book "Cells: Structure and Function"	$ 3.95	
1	Book "Essentials of Parisitology"	7.95	
1	Book "Venereal Disease"	1.95	
1	Book "Communicable Disease"	1.50	
1	Book "Reducing the Risk of Noncommunicable Disease"	2.25	
1	Book "Programmed Review of Organic Chemistry Nomenclature"	2.95	
1	Book "Programmed Review of Organic Chemistry Reactions"	4.95	
1	Book "Inorganic Nomenclature"	5.53	
1	Book "Miniaturized Microbiological Methods"	15.19	
1	Book "Bacteriophages"	5.65	
1	Book "Practical Mycology"	6.84	
-	- Instructional Booklets (Carolina Biological Supply)	13.77	
-	- Oxford Biology Readers (Carolina Biological Supply)	30.46	
Total Books			408.61
Slides, Filmstrips, Cassettes-consisting of individualized instruction programs			3,225.50
Sealed Cultures			289.87
Blood Testing Kits			131.52
Chemicals			676.53
Live Creatures			49.00
Biological Slides			186.33
Software and Glassware Supplies			1,121.57
Operating Office Supplies			193.32
XEROX Copier Supplies			124.15
Photocopies Taken at UNH			51.42
Film Processing			40.40
Repairs to Microscope			156.28
Total Supplies and Materials Actually Used in Project..................			$6,655.00

APPENDIX C

(EQUIPMENT)

1975/76

Equipment

1)	Attachments for Polaroid MP-4 Multi-Purpose Land Camera - macro extension, "100: series pack film holder, "50" series 4x5 sheet film holder, standard ground glass, 35mm Tominon reverse Tessar-type lens. (Polaroid Corporation)	$ 348.40
2)	Shutter, microscope adapter and aerial image focusing screen. (Polaroid Corporation)	86.50
3)	Microscope, Trinocular, Head rotates 360° Interpupillary adjustment in head, adjustable range of 55/71mm., adjustable eye pieces. Rectangular stage with built-in graduated mechanical stage with co-axial drive. Co-axial coarse and fine adjustment knobs. Built-in substage lamp. One pair wide field oculars with pointer. (Kenneth A. Dawson Co.)	750.00
4)	Stereo zoom 7 Power "A" Pod. B & L Model AV-1070P (Kenneth A. Dawson Co.)	834.00
Total Equipment		$2,018.90

FINAL REPORT BUDGET

As of June 30, 1977

TITLE OF PROPOSAL: Microbiology Modules

DIRECTOR: Dr. Raymond Walke

INSTITUTION OR AGENCY: New Hampshire Vocational Technical College, Berlin, N. H.

BEGINNING DATE: July 1, 1976 ENDING DATE: June 30, 1977

GRANT AMOUNT: $2,981.00 RECEIVED TO DATE: $2,907.37

I.	DIRECT COST		
	A. Director: Dr. Walke - 225 Hours @ 5.4775/Hr.	$1,232.44	
	B. Employee Benefits - Social Security	222.86	
	C. Travel - Provided by NHVTC-Berlin	- 0 -	
	D. Supplies and Materials Actually Used in Project (See Appendix A)	1,397.25	
	E. Communications - Provided by NHVTC-Berlin (See Appendix B)		
	F. Services - Provided by NHVTC-Berlin (See Appendix B)		
	G. Final Report Cost - Provided by NHVTC-Berlin (See Appendix B)		
	H. Equipment (None purchased)	- 0 -	
	Subtotal - Direct Cost		$2,734.83
II.	INDIRECT COST		172.54
III.	TOTAL COST		$2,907.37
IV.	COST SHARING (See Appendix C)		

APPENDIX A

(MATERIALS & SUPPLIES)

1976/77

A. Books

1	Book "Practical Mycology"	$ 9.31
1	Book "Individual Study Program in Chemistry-13 Volumes	11,01
1	Book "H G S Molecular Structure Models"	7.20
2	Books "Chemical Bonding"	6.67
2	Books "Soil Microbiology"	56.20
2	Books "The Historical Background of Chemistry"	
2	Books "Bacteriophages"	
1	Book "Actinomyatades Characteristics and Practical Import"	16.25
2	Books "From Vital Force to Structural Formulas"	11.50
1	Book "How to Know Lichens"	4.95
1	Book "How to Know Living Things"	4.95
1	Book "How to Know Mosses and Liverworts"	4.95
1	Book "How to Know Non-Gilled Fleshy Fungi"	6.95
1	Book "How to Know Protozoa"	4.95
1	Book "How to Know Tapeworms"	5.95
1	Book "How to Know Trematodos"	7.20
2	Books "Advance of the Fungi"	8.78
2	Books "The World of Mosses"	11.39
2	Books "The Biology of Lichens"	40.02
2	Books "The Biology of Fungi, Bacteria and Viruses"	
1	Book "The Pictorial Key to Genera of Plant"	10.10
2	Books "The Biology of Slide Moulds: Study in Biology No. 56"	7.22
2	Books "Understanding the Chemistry of the Cell"	4.50

1	Book "Mosses with Hand Lens & Microscope"	$15.55	
2	Books "The Soil and Health: A Study of Organic Agriculture"	10.25	
-	- "Oxford Biology Readers"	74.59	
2	Books "Nematodes" Biological Series	7.75	
4	Books "Chemical Symbols - Powell Programmed Units in Chemistry"	6.39	
2	Books "Freshwater Ecology"	8.06	
2	Books "Soil Ecology"	8.06	
2	Books "Terrestrial Ecology"	8.06	
3	Books "How to Know the Aquatic Plants"	11.88	
3	Books "How to Know Beetles"	14.28	
3	Books "How to Know Butterflies"	11.88	
3	Books "How to Know the Immature Insects"	11.88	
3	Books "How to Know Mosses and Liverworts"	19.80	
3	Books "How to Know the Lichens"	11.88	
3	Books "How to Know the Non-Gilled Fleshy Fungi"	16.68	
3	Books "How to Know Pollen & Spores"	11.88	
3	Books "How to Know Protozoa"	11.88	
3	Books "How to Know Weeds"	13.01	
1	Book "Structure of the Cell"	34.61	
B.	Total Books		$ 548.42
C.	Chemicals		227.63
D.	Slides, Tapes and Booklets		355.64
E.	Soil Organism Study Kit		20.89
F.	Live Creatures		100.25

G.	Operating Supplies - Office	$ 137.76
H.	Copies Taken at UNH	6.66
	Total Supplies and Materials Actually Used in Project	$1,397.25

APPENDIX B

(COST SHARING)

1976/77

I.	TIME - COSTS		
	- Administration - Director, Deans	$ 500.00	
	- Secretarial Assistance	300.00	
	- Accounts Purchasing	750.00	
	- Concord Agencies (Cost Sharing)	100.00	
	- Custodial - Book Store	200.00	
			$1,850.00
II.	CURRENT EXPENSES		
	- Administrative	250.00	
	- Supplies	1,000.00	
	- Heat, Light, Power	200.00	
	- Postage	75.00	
	- Telephone	100.00	
			$1,625.00
III.	EQUIPMENT (Estimated)		5,000.00
IV.	TRAVEL		70.00
V.	FINAL REPORT COSTS (1975/76 Cost Sharing)		
	- Paper	100.00	
	- Covers	50.00	
	- Mimeographing (Stencils)	50.00	
	- Typing (3 Weeks @ $118.77 per week)	356.31	
			$ 556.31
	TOTAL		$9,101.31

Sub-Section VII: BIBLIOGRAPHY

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Sub-Section VIII:

ENVIRONMENTAL MICROBIOLOGY MODULES

APPENDIX E

ENVIRONMENTAL MICROBIOLOGY

Raymond H. and Jayne G. Walke

PREFACE

The Vocational Technical College has been instituted to provide technical education to those students who desire more background than high school has provided, but for one or more reasons do not wish to attend four year college programs. It has been observed in the Natural Resource Management Program at NHVTC-Berlin that most of the students entering this science-engineering curriculum lack sufficient background to cope with the technical nature of college work.

Through the course of two years a series of modularized mastery-orientated modules has been developed to aid the student in the areas of biology, chemistry, and microbiology so that environmental microbiology can also be mastered.

Ten Theoretical Modules (TM's) have been put to use at NHVTC-Berlin which include materials which:

1. Will stimulate student interest and concern, and show both the weaknesses and strengths which characterize the student profile. Evaluation quizzes will be self-corrected and than analyzed with a tutor and/or instructor.

2. Will show the historical development of the concepts now blocked into the module.

3. Will, through the use of tutors and practice, perfect the manipulative and analytic techniques which must be mastered in microbiology.

4. Will, through use of visual and audio mechanisms, develop the difficult concepts as well as the manual skills inherent to the area of concern.

5. Will provide completion tests which will indicate mastery of the material or will indicate the portions of the module which must be repeated.

6. Will allow the instructor to help whenever problems arise that are not handled by the modular approach.

7. Will develop confidence and eliminate the insecurity which so often manifests itself in poor rapport between student and teacher and student and science courses.

8. Will encourage the student to read and research further into the areas which have stimulated interest.

9. Will assure that scientific information received in the future from any source is sorted and filed in the memory circuitry in an orderly, retrievable form.

10. Will facilitate the introduction of the practical modular units which follow.

Twenty specialized modules dealing with Environmental Microbiology (EM's) have been produced utilizing A-V equipment, programmed texts, self-correcting quizzes and mastery tests which allow the student to delve into specialized areas of the natural world which are often neglected or at best covered lightly in conventional microbiology courses.

It must be emphasized that both student and instructor are using individually oriented self-paced materials. Students will move at their own speed. Each module is meant to be mastered and if end-of-module tests are not satisfactory to the student an opportunity to repeat the module "in toto" or piecemeal should be available. The instructor and all tutors who help to correct material or guide students over rough spots must themselves have completed the module and have the background to aid. The teacher now must TEACH and the student is expected to work diligently and LEARN.

To purchase the necessary texts, references, filmstrips, tapes, slides, kits and non-durable materials requires not only a large initial investment, but yearly replenishment. The modules can best be used as a core around which a teacher, in cooperation with local administration can offer an innovative fresh approach to some traditionally 'tough' subject material. Tests and quizzes will have to be designed to fit local needs. Substitutions of other texts and references may be required. Certainly within a short period of time updating will be necessary.

These modules will, it is hoped, awaken in students an awareness of areas microbiological that were unknown before their use.

Raymond H. Walke, Ph.D.
Jayne G. Walke
Initiators

Natural Resource Management
NHVTC-Berlin
Berlin, NH 03570

June 1977

CONTENTS

THEORETICAL MODULES

TM-1 ATOMIC THEORY

TM-2 THE PERIODIC TABLE

TM-3 SOLUTION CHEMISTRY

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA

TM-5 PROBLEMS OF CLASSIFICATION

TM-6 BASIC LABORATORY TECHNIQUES

TM-7 CHEMICAL BONDING

TM-8 ORGANIC CHEMISTRY

TM-9 ACID-BASE, REDOX & ELECTROCHEMISTRY

TM-10 CELL CHEMISTRY & STRUCTURE

ENVIRONMENTAL MICROBIOLOGY MODULES

EM-1 BACTERIAL ECOBIOLOGY

EM-2 VIRUSES

EM-3 NEMATODES

EM-4 PLANT PATHOLOGY

EM-5 WATER & WASTEWATER MICROBIOLOGY

EM-6 BACTERIA

EM-7 MICROBIOLOGICAL METHODS

EM-8 SLIME MOLDS

EM-9 FUNGI

EM-10 LICHENS

EM-11	ACTINOMYCETES
EM-12	FERNS AND FERN ALLIES
EM-13	LIVERWORTS
EM-14	MOSSES
EM-15	ALGAE
EM-16	PARASITOLOGY
EM-17	AQUATIC MICROBIOLOGY
EM-18	SOIL MICROBIOLOGY
EM-19	PROTOZOANS
EM-20	ADVANCED ANALYTICAL TECHNIQUES

A NOTE TO THE STUDENT

These modules have been disigned to involve you - deeply - in areas of science of which you probably have not been more than slightly aware.

The methods used require that you really learn the material. FOR THE MOST PART, by yourself.

To benefit from this course you should understand these basic facts:

1. You will meet with the instructors only on occasion (usually one hour/week) to iron out difficulties, introduce new areas, discuss and plan for help in areas of concern to several students.

2. You will be assigned laboratory time to work on modules and/or discuss problems with instructors or tutors. Quizzes and tests are usually taken at this time.

3. You may check out materials overnight or on weekends provided they are returned promptly for others to use. Forms for this are provided by the department.

4. You are expected to complete a minimum of one module over each two month period so that a minimum of nine modules will be completed in two years. At NHVTC-Berlin credit is accumulated at a rate of one credit per three modules.

5. You are encouraged to complete more than nine modules. Indeed, it is to your benefit to complete all thirty modules and receive ten credits, since you will receive more knowledge for the same tuition cost!!!!

6. You may repeat portions of all of a module to improve your mastery. At NHVTC-Berlin a minimum modular average of 75% is required, that is, grades should be a 'C' or better.

7. You will be exposed to several forms of programmed learning, but all teachers using this approach stress one common point. If you look ahead, copy, try to outguess the quizzes then you CHEAT YOURSELF.

8. You can skip portions of modules or whole modules and obtain credit if you can show the instructor that you possess those skills by written test and by practical demonstration.

9. You must be able to share materials. This course is very expensive no matter how it is organized. If another student has materials you need be prepared to work on other modules. You do not have to work in sequence and you may work on several modules simultaneously.

10. You will do well, learn a great deal, and avoid frustration if you plan to work on a schedule and aim for perfection.

THE RESULT WILL BE CONFIDENCE IN YOUR COMPETENCY IN ENVIRONMENTAL MICROBIOLOGY.

A NOTE TO INSTRUCTORS

No two instructors are anywhere near alike...in backgroubd, in experience, in education. These modules are neither complete nor free from error. The developers used references and literature available in Northern New Hampshire and slanted the presentation to the students encountered in their classrooms.

Certainly the basic texts used to back up these modules can be replaced by those available elsewhere. The programmed reviews may have to then be revised. Articles of the instructors choice may replace those chosen by these writers, especially if they emphasize problems or creatures encountered locally.

This course at NHVTC-Berlin extends over a two year period. Students meet with the instructor - en masse - only once a week. It is in the MOD TIME, the open-time, when students work in the resource room or laboratory that teaching takes place. The instructor must be where "the action is" and not only aid the student at the microscope or with difficult analyses, but must encourage and give praise when the student makes that first"stained slide" or really "pegs down" an organism to genus and species.

At NHVTC-Berlin, this course is intimately associated with two other courses: ENVIRONMENTAL FIELD IDENTIFICATION and DATA STORAGE AND INFORMATION RETRIEVAL.

In F. I. D. or "Kritter-time", as we call it, all manner of things natural are studied with the aim of gradually developing an understanding of classification. Elements and chemicals become familiar in Environmental Microbiology; minerals and rocks are classified both in courses and in Environmental Field Identification; soils are studied in the winter when the 7th Approximation as well as older taxonomic schemes are introduced. Higher plants and animals are studied as they develop through the seasons: fall flowers, winter buds and twigs, and spring flowers; whatever the season when a creature is found that requires the microscope that module is stressed which fits the "kritter". Often the students bring in the diseased tree branch, the algal scum, the seaweed, the tiny nematode or microarthropod from their studies in other Natural Resource Management courses. This is the reason for the F. I. D. notebook. The student observes, draws, dissects, tests, researches, and gradually the skills develop...PATIENCE, DILIGENCE, a RESPECT for DETAIL. By the end of the second year the student has developed confidence; NATURE CAN BE UNDERSTOOD!

The Data Storage and Information Retrieval course encourages the student to utilize the library, to delve deeper into a problem area, and then to store the valuable information in a private retrieval system. The end-of-module tests are sufficiently difficult to require that the facts from reading and searching be obtained for the DATA STORAGE DECK.

This course requires that much be covered, much stored, and much retrieved. It is not based upon memorization of facts, but upon organizing the mind to cover the wide range of material making up ENVIRONMENTAL MICROBIOLOGY.

A space shoud be provided for the boxes or kits, for the storage of slides, tapes, microscope slides, cassettes, and all the other materials which must be shared by students. These materials must be checked out and back in on time and locked up safe from the few students who would hoard materials.

These modules may be incorporated into existing courses to augment the text or to provide enrichment beyond a text. The modules on Nematodes, Slime Molds, Actinomycetes, Protozoans, and Algae may be especially useful. The instructor may develop a module that fits the student and the school using these modules as guides. Perhaps your own will really be the BEST. Only you know your students as we know ours.

TM-1 ATOMIC THEORY INSTRUCTION AND CHECKOFF SHEET

DATE STARTED: ______________

INTRODUCTION:

Read Historical Background of Chemistry - pp. 1 - 119. (Leicester)
Listen to Alchemy Tape. Date Completed: _______
Discuss with Instructor or assistant (Oral Quiz)
Instructor signature: _____________

PACKET #1:

Read The Historical Development of Chemistry - pp. 119-162. (Leicester)
Request Programmed Review Date Completed: _______
After doing programmed review, request self-quiz.
Instructor signature: _____________

PACKET #2:

Read and make 3" x 5" cards on each scientist and list achievements in the Atomic Energy's Commission publications on the ATOMIC PIONEERS, I, II, & III.
Request end of packet quiz. Date Completed: _______
Instructor signature: _____________

PACKET #3:

Read THE CHEMICAL ELEMENTS - pp. 1-17. (Davis)
Read THE HISTORICAL BACKGROUND OF CHEMISTRY - pp. 164 - 171. 189-195. (Leicester)
BE SURE TO PRODUCE 3" x 5" CARDS ON PERSONS, TERMS, PLACES & ELEMENTS.
Request Programmed Review. Date Completed: _______
Request end of packet quiz.
Instructor signature: _____________

PACKET #4:

Utilize Slide-Tape Presentation #821 - ATOMIC WEIGHTS, MOLECULAR WEIGHTS & THE MOLE CONCEPT. Take self-quiz and submit to instructor.
Utilize Slide-Tape Presentation #851 - ELECTRON CONFIGURATION AND THE ORBITAL DIAGRAM. Take self-quiz and submit to instructor.
Date Completed: _______

Instructor signature: _____________

PACKET #5:

Request the programmed text material. Date Completed: _________

Instructor signature: _____________

PACKET #6;

Request programmed materials concerning the mechanics of elementary chemistry.

Date Completed:________

Instructor signature:______________

HISTORICAL REVIEW QUIZ__________ DEVELOPMENT OF SCIENTIFIC THOUGHT__________

WRITTEN EXAM__________________ DATE MODULE COMPLETED____________________

Instructor signature:______________

TM-1 ATOMIC THEORY

PURPOSE:

To encourage the student to follow the historical development of chemical theory from Ancient Times to our Modern Period.

MATERIALS:

1. Text: Leicester, H.M., The Historical Background of Chemistry, John Wiley & Sons.

Other historical and philosophical texts concerning chemistry organic chemistry, biochemistry, and microbiology are useful.. At NHVTC-Berlin supplemental text work is assigned in the DATA STORAGE AND INFORMATION RETRIEVAL course which augments Environmental Microbiology and in the course - ENVIRONMENTAL FIELD IDENTIFICATION.

2. White Magic & Alchemy Cassette, Canadian Broadcasting Co. The Center Cassette Studies, Inc., 8110 Webb Ave., N.Hollywood, Cal.

3. Davis, H.M. The Chemical Elements. Ballantine Books. (Again any of several paperbacks on the Elements may be substituted.)

4. Powell, V.P. Chemical Symbols, Prentice Hall, Inc., Englewood Cliffs, N. J.

5. Atomic Pioneers, Books I, II, and III; IB-009, IB-010, and IB-011 from USAEC-Tech Info. Ctr., Box 62, Oak Ridge, Tenn. 37830.

6. Communication Skills Corporation Slide-Tape Presentations.

#831 Atomic Weights, Molecular Weights and the Mole Concept.

#851 Electron Configuration and the Orbital Diagram.

Communication Skills Corporation, P.O. Box 684, Fairfield, Connecticut 06430.

7. A college chemistry text of instructor's choice as reference material.

OBJECTIVES: To enable the student to:

1. Follow and sense man's development of the basic concepts of biochemical thought.

2. Use chemical symbols.

3. Draw simple orbital diagrams.

4. Determine electron configuration.

5. Calculate molecular weights of compounds.

TN-1 ATOMIC THEORY

INTRODUCTION:

It is impossible to understand the way our microbiological environment operates without recognizing that it is part of an ever increasing body of knowledge known as science. Your first task is to recognize that scientific development has roots as far back as man thought.

You are asked to read leisurely the Preface and the first few chapters of Leicester's classic: The Historical Background of Chemistry; taking notes on terms, people and concepts. (Placing each concept, person and term on a separate 3" x 5" card is suggested.)

When you have compketed this section and you have not heard the tape, ALCHEMY, request it and listen and take notes on it.

This first unit will be discussed with the instructor or a laboratory assistant in small goups (or alone). You may have notes and cards.

BEAR IN MIND that a CRITICAL PERSONAL WRITTEN appraisal of the history of scientific development will be expected at the end of this module.

ALL THE BOOKS FOR THIS MODULE WILL BE ON RESERVE IN THE LIBRARY FOR AN EXTENDED PERIOD OF TIME.

REMEMBER THAT WHEN YOU START THIS MODULE YOU WILL HAVE TO OBTAIN AN ASSIGNMENT AND EVALUATION SHEET FROM YOUR INSTRUCTOR. KEEP ONE IN YOUR NOTEBOOK AND ONE MAY BE PUT INTO YOUR FOLDER SO THAT A RECORD OF YOUR STARTING THIS MODULE IS RECORDED.

TM-1 ATOMIC THEORY
PACKET #1 PROGRAMMED REVIEW

1. During the late 17th century the attention of chemists was drawn to the nature of ______________ and the ______________ which held compounds together.	
2. Advances in practical, ______________ chemistry, further knowledge about elements and compounds, the wide application of __________ methods made possible the foundation of the __________ school of Lavoisier.	1. combustion forces
3. The ancients knew and the 17th century chemists knew that something was __________ from a burning object.	2. analytical quantitative French
4. When metals were heated however, they were converted to a ____________ powder called _________, which we now call an oxide.	3. escaping For example: $C + O_2 \rightarrow CO_2$ wood + $O_2 \rightarrow$ ash + CO_2 THEY COULD NOT SEE THIS!!!
5. It was ______________ who believed that air contributed something to life and flame. The Scotch alchemist Alexander Seton and his follower Michael Sandovigius suggested that air contained a __________ ________ that nourished life.	4. heavier calx FOR EXAMPLE: $Fe + O_2 \rightarrow FeO$ Iron + oxygen → iron oxide (iron calx)
6. Robert ______________ experimented with the ______________, S, trying to burn it in a vacuum. What happened?	5. Paracelsus vital spirit
7. Disregarding opposing facts a __________ to explain combustion was developed by Johann Joachim ____________ and Georg Ernst ___________. A weightless inflammable principle existed in combustible matter called ______________.	6. Boyle Elemental sulfur No reaction, oxygen or some other oxidizer like chlorine or bromine, is necessary for combustion.
	7. theory Becker Stahl Phlogiston

8. Not all chemists were swayed by the ___________ theory. Boerhaave of ______________, Holland influenced ______ ______ in his development of caloric theory and _________ in his theory of latent heat.

9. But if ___________ was weightless why when a substance like metal was burned and lost phlogiston did it ______________ in weight?

8. phlogiston
Leiden
Lavoisier
Black.

10. Boerhaave had suggested that ________ might have a chemical function. Joseph ____________ in heating magnesia alba (basic magnesium carbonate) proved that a _____________ evolved. This was the _________________ of _________________.

9. phlogiston
increase (gain)

11. Now it was known that gases could take part in ____________. Daniel _____________, Black's student separated air into the active part and non-active residue he called ______________ air. Cavendish and ______________ then found this gas we call __________________________.

10. air
Black
gas
gas sylvestre
Van Helmont

$Mg_2(OH)_2(CO)_3 \xrightarrow[\Delta]{} 2MgO + H_2O + CO_2\uparrow$

NOTE: How carbonates when heated yield carbon dioxide

$MgCO_3 \xrightarrow[\Delta]{} Mg + CO_2\uparrow$

$CaCO_3 \xrightarrow[\Delta]{} CaO + CO_2\uparrow$

$BaCO_3 \xrightarrow[\Delta]{} BaO + CO_2\uparrow$

$SrCO_3 \xrightarrow[\Delta]{} SrO + CO_2\uparrow$

12. A dissenting clergyman, turned chemist, Joseph ______________ invented ________ which is nothing more than __________ dissolved in water. He also produced nitric Oxide (NO) by treating _____________ with spirit of nitre (nitric acid).

11. chemical reactions
Rutherford
mephitic
Scheele
nitrogen

NOTE: air is by volume 78% nitrogen (N), 20% oxygen 1% inert gases including Argon, A; Helium, He; Krypton Kr; Neon, Ne; Radon, Rn; Xenon, Xe; traces of CO_2, SO_2 *and pollutants.*

12. Priestly
soda water
carbon dioxide
metals

13. Now both Priestly and ______________ discovered 'even purer' air, the element ______________. They utilized 'mercurous calcinates perse', the compound we know as ____________________.	
14. In 1783 ________________ attacked the phlogiston theory armed with the findings of Bayen and _____________, and his extensive ________________ chemical studies. The true nature of ____________ was now understood. It was made of two parts ____________ and one part ____________. It is ironic that the greatest 18th century chemist, __________ ended in the ________________.	13. Scheele oxygen mercuric oxide $2HgO \xrightarrow[\Delta]{} 2Hg\downarrow + O_2\uparrow$
15. Side by side with the evolution of the false ________. Theory went the growth of a theory of chemical ____________. The term dates back to Albertus ______________ and Jabir known as ________________. Substances seem to possess what the Chinese thought love and _____________, yin and ______, maleness and ______________.	14. Lavoisier Priestly quantitative water hydrogen (H) oxygen (O) $2H_2O \rightleftharpoons 2H_2 + O_2$ Lavoisier guillotine
16. Now the _____________ nature of this affinity was obvious. Could it be measured? Wilhelm ________________, C.F. ______________, and Richard ________________ all worked to find how much of an _____________ existed. They tried to ________________ their chemical findings.	15. Phlogiston affinity Magnus Geiber hate yang femaleness
	16. qualitative Homberg Wenzel Kirwan affinity quantify

17. Chemists wanted to draw up tables of ____________. Man seems to want to ____________ and pigeonhole in ________, all of nature. In 1718, Etienne-Francois ___________ tried to draw up such a table. The Swedish chemist, Torbern ___________ produced a table built around the reactions we now call _____________ and double ______________.	
18. First used by the Florentine glass blowers the ____________ became a common laboratory tool. The Swedes, A.F. ______________, Torbern ______________ and his student J.G. ___________ used this dry analytical method to discover new ___________________.	*17. affinity classify groups Geoffroy Bergman displacement decomposition $Zn + CuSo_4 \longrightarrow ZnSO_4 + Cu\downarrow$ (displacement) $Na_2SO_4 + BaCl_2 \dashrightarrow BaSO_4\downarrow + NaCl$ (double displacement or double decomposition Note how zinc 'forces' copper out of the copper sulfate compound (blue vitriol) to produce zinc sulfate. In the second reaction sodium sulfate and barium chloride are dissolved in water...but when mixed the 'affinity' of barium for sulfate produces a precipitate... elements have switched affinities.*
19. The first actual percent composition was reported by Martin H. ______________________.	*18. blow pipe Cronstedt Bergman Gahn elements*
	19. Klaproth

20. In 1754 C.F. ______________, Lavoosier's teacher explained the nature of a salt. Acids and ____________ react to give ___________ and water.

21. The discovery of elements proceeded rapidly with the discovery of the ____________ trough by ____________ the botanist. Complete the following table:

CO	________________	1737
____	bismuth	1757
Pt	________________	1740
Zn	________________	1746
____	nickel	1754
____	manganese	1774
Mo	________________	1781
____	tellurium	1782
W	________________	1785
Cr	________________	1798

22. The oxides of other new ___________ were found in the 1700's. Write the names of the metals derived from these oxides: ZrO ____________; SrO ___________; Ti_2O_3 ____________; and Y_2O_3 _________________________.

23. These oxides if treated with carbon at high temperature will yield ____________ and the gas sylvestre we call ___________________.

20. Rouelle
bases
salt

Ex: $HCl + LiOH \rightarrow LiCl + H_2O$
LiCl is a salt
HCl is an acid
LiOH is a base

21. pneumatic
Hales
Cobalt
Bi
Platinum
Zinc
Ni
Mn
molybdenum
tungsten
chromium

22. elements
zirconium
strontium
titanium
yttrium

23. metals
carbon dioxide

$2ZrO + C$	$2Zr + CO_2$
$2SrO + C$	$2Sr + CO_2$
$2Ti_2O_3 + 3C$	$4Ti + 3CO_2$
$2Y_2O_3 + 3C$	$4Y + 3CO_2$

24, The attempts of Homberg, Wenzel and Kirwan encouraged the experiments of Benjamin _______________ who first wrote Outline of _____________________. He utilized the law of conservation of matter. He produced the first table of __________________________.	
25. Then in 1802, Ernst Gottfried_______________ translated the French of ______________________ into German and put together a truly useful ________________ table.	24. Richter Stoichiometry (from the Greek meaning to measure something which cannot be divided. equivalents
26. Another French chemist Joseph Louis ______________ gave practical proof of the law of constant proportion. Kurnakov in 1914 suggested that alloys and other compounds of indefinite composition be called __________________ and those of ordinary compounds be called ____________________. Explain why.	25. Fisher Berthollet affinity
	26. Proust berthollides daltonides

27. But William __________, the developer of quantitative ______________ theory and then John _______ combined the concepts of _____________ combination and the law of _______________ proportions. Then John _______ devised a set of _______________ to express his theory. Hydrogen (H) was _____; Oxygen (O) was ____; and Carbon (C) was ______. What were the symbols for water, ammonia, carbon dioxide, and sugar? __________, ____________, ____________, and _____________.

NOTE: Dalton was not very close to correct in many of his ideas, but he saw atoms as individual entities with properties. Dalton's laws can be stated as:

1. All matter is composed of atoms and these atoms can be neither subdivided not changed one into another.

2. Atoms can be neither created or destroyed.

3. Atoms of a particular element are identical in size, shape, mass, and all other properties and differ from atoms of other elements in these properties.

4. Chemical change is the union or separation of atoms.

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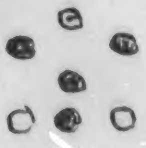
27. Higgins
atomic
Dalton
atomic
multiple
Dalton
symbols
H ⊙
N ⦶
O ○
C ●
H_2O ⊙ ○
NH_3 ⦶ ⊙
CO_2 ○ ● ○
$C_{12}H_{22}O_{11}$



28. Thomas __________ and his friend William Hyde ______________ (Wollastonite is a mineral, $CaSiO_3$) confirmed the law of multiple ____________ in 1808. Thompson showed that potash (K_2O) and _________(SrO) combined with ____________ acid, $H_2C_2O_4$, to form ___________ sets of salts, one of which contained twice as much as the other.	
29. The elements selenium (Se), silicon (Si) and titanium (Ti) were discovered by Jons Jacob __________________, a Swedish chemist who recognized that one atom of an _______________ might combine with varying numbers of __________________ other elements.	28. Thomson Wollaston proportions strontia oxalic two
30. Atomic ____________were determined by J.J.___________ using the rule which states that the product of the _______________ weight and ______________heat for an element is __________________. This concept is called the (P.L.) ______________ and (A.T.) __________ _________ Rule.	29. Berzelius element atoms NOTE: He could not tell whether two atoms combined with 2, 4, or 6 other atoms. As long as the concepts of molecular weight did not exist no difference could be recognized between the OH (Hydroxyl group) and H_2O_2 (Hydrogen Peroxide group).
	30. weights Berzelius atomic specific constant Dulong Petit

31. Two substances often crystallize in similar forms. They are said to be ______________. This concept was first used by E. ______________, who said if they were similar in form they had analogous ________________.	
32. When dealing with gaseous compounds the Law of Combining ____________ is used. This is often called the ____________ Law after the French chemist. It stated that the __________ of the volumes of reacting gases were small ____________ numbers.	31. isomorphous Mitscherlich formulas
33. The Italian chemist Amadeo ____________ was first to discover that equal volumes of ______________ gases contained the same number of ______________. Unfortunately, the chemical theorists Berzelius and J.B.A. ____________, his successor, did not accept Avogadro ________________ and it was not until S.____________ suggested that all atomic __________ be compared to 1/2 a molecule of ___________ that a table of ____________ weights was possible.	32. Volumes Gay-Lussac ratios whole Example: $N_2 + 3H_2 \longrightarrow 2NH_3$
34. As early as 1815 William ____________ had suggested that __________ might be the prime matter of the ancients. Berzeiius suggested that the ____________ letter of the Latin name of the ________________ be used as its chemical __________________, and that if two elements began with the same letter the next ____________ letter of the name was to be added.	33. Avogadro different particles Dumas hypothesis Cannizzaro weights hydrogen atomic
35. The true composition of acids was discovered after great controversy in 1810 when Humphrey _________ proved that ________ was an element and that muriatic acid (HCl) contained no ____________ Justus von _________ first recognized that it was the ________________ in acids which was the acid moiety.	34. Prout hydrogen first element symbol distinctive
	35. Davy chlorine oxygen Liebig hydrogen

TN-1 ATOMIC THEORY
PACKET #1 SELF - CORRECTING - QUIZ

TRY THIS QUIZ AND SEE WHAT YOU RECALL.

FILL IN THE BLANKS IN THE SPACES PROVIDED.

1. During the second half of the 17th century and throughout the 18th century chemists struggled with the problems of the nature of ____________________..

2. The leader of the French school of modern chemistry was ____________________.

3. Calx (an oxide) is produced when a ______________ is heated in air (O_2).

4. The first person to recognize that air is necessary to life was ____________. Alexander Seton, the _______________, and Michael Sendivogius introduced the _____________force (spirit) theory.

5. Robert Boyle (Boyles' Law) proved that combustion required air by attempting to burn sulfur in a _______________.

6. Johann Joachim ________________and his pupil Georg Ernst ________________ formulated the most influential (and completely incorrect) theory which held sway throughout the 18th century. This was the ____________Theory.

7. The first science-engineering text was De Re Metallica by _______________. It was translated by President and Mrs. ____________________.

8. Compounds to Becher and Stahl were called ____________________.

9. Mixts to 18th century chemists are what we now call ____________________.

10. "The original _________________ could never be isolated" said 18th century chemists, "for they could not leave one ___________ without entering another."

11. Becher accepted air, water, and earth as ______________; Stahl added fatty ____________ which he called ___________________ (a term invented by Hapelius in 1606).

12. If phlogiston was _________________how was it possible to ignore the increase in weight of metals upon calcination? This was the downfall of the _______________theory.

13. The order of reactivity of metals was first listed by Albertus _____________ and the 'master' chemist of the Muslim world ______________ (ja'far al Sadiq).

14. The concept of chemical replacement was "Table des differents rapports" by Etienne-Francois _______________________. (____________ the Elder).

15. The Swedish chemist Torbern _________________ differentiated between ______________ chemistry (aqueous) and _____________ chemistry (fusion). He also discovered single and _________________displacement or _____________.

16. Acid- _______________ titration (how much base to neutralize and ___________) was quantified by Wilhelm __________________ in 1700.

TM-1 ATOMIC THEORY
PACKET #1 - SELF - CORRECTING QUIZ (cont.)

17. Rates of solution of metals in ______________ were studied in 1777 by C.F. ____________________.

18. Richard _____________ measured what are now known as ____________ weights as early as 1781.

19. In the 17th and 18th centuries analysis using a ____________ was especially common. This method was started by the Florentine glass blowers. NOTE: Florence flasks are still used today.

20. While working on developing "wet" analysis _____________ also discovered how to make _____________ from beets. Greatest of the 'wet' chemists was Torbern ______________________.

21. Martin H. _________________, the best alanyst of the 18th century, was first to recognize that precipitates must be ______________ before weighing them.

22. The Swedish chemist Carl Wilhelm ______________ discovered the gas _________ and the solid elements Mn, ____________; Mo, ______________; W, ___________ and As, _________________. He also found HF, ________________.

23. The Swedish chemist Carl Wilhelm ______________, besides working with gases and solid elements worked with the organic chemicals: HCN, ___________; lactic, citric and malic _________ and the trihydoxy alcohol ______________.

TM-1 ATOMIC THEORY
PACKET #2

THIS ASSIGNMENT SHOULD BE ACCOMPLISHED AS LEISURE READING.

AFTER A FEW PAGES ARE DIGESTED COMPLETE THE 3 " x 5" INDEX CARDS ON THE SCIENTISTS DISCUSSED.

WHEN YOU KNOW THE PEOPLE AND EVENTS WELL REQUEST THE SELF-CORRECTING QUIZ...

SEE HOW YOU DO AND MOVE ON TO PACKET #3 IF YOU HAVE MASTERED THIS PACKET.

TW-1 ATOMIC THEORY
PACKET #2 SELF QUIZ A ATOMIC PIONEERS

MATCHING

1. ______________ Newton
2. ______________ Cockcroft & Walton
3. ______________ Zeeman
4. ______________ Bohr
5. ______________ Pythagoras
6. ______________ Gassendi
7. ______________ Mendeleev
8. ______________ Lavoisier
9. ______________ Democritus
10. ______________ Fermi

A. splitting a spectral line into components of slightly different frequency when a light source is placed in magnetic field.

B. Periodic Table of Elements in order of Atomic Weights - the first scientist to do this.

C. Quantum Theory to explain the hydrogen spectrum.

D. Transmutation of atomic nuclei with artificially accelerated atomic particles.

E. "A given amount of matter, whether in the solid, liquid or gaseous state, has a total mass, as measured by a weight that remains the same."

F. set off first self-sustaining nuclear chain reaction.

G. discovery of light spectrum led to our understanding of internal structure of the atom

H. opposed idea of atomicity

I. World's first great atomic philosopher

J. Strongly advocated experimentation in science.

TM-1 ATOMIC THEORY
PACKET #2 SELF QUIZ B ATOMIC PIONEERS

1. ____________ Faraday

2. ____________ The Joliot-Curies

3. ____________ Mosley

4. ____________ Lawrence

5. ____________ Dalton

6. ____________ Hahn & Meitner

7. ____________ Proust's Law

8. ____________ Rutherford

9. ____________ Rayleigh

10. ____________ Archimedes

A. All compounds contained elements in certain definite proportions

B. NEW SYSTEM OF CHEMICAL PHILOSOPHY-1808

C. Idea of relative densities of bodies helped show that man could analyze the relative weights of substances.

D. laid foundation for electochemistry and electro-magnetic induction

E. "Father of Nuclear Science"

F. discovered protactinium

G. discovered first rare atmospheric gas-argon

H. Nobel Prize in Chemistry for discovery of new radioactive elements prepared artificially

I. invented cyclotron

J. X-ray spectra of the elements

TN-1 ATOMIC THEORY
PACKET #3 THE CHEMICAL ELEMENTS, FUNDAMENTAL ELEMENTS
PROGRAMMED REVIEW

NOTE: AS YOU READ THE TEXT WORK ASSIGNED BE SURE TO PRODUCE 3" x 5" CARDS ON PERSONS, TERMS AND ELEMENTS. THE END OF THE PACKET SELF QUIZ WILL CONTAIN QUESTIONS ON ALL THE TEXTS BY DAVIS, LEICESTER AND FROM AEC BOOKLETS.

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1. A unit quantity of an element is called an ____________. Atoms are made up of three major parts: _________, ___________, and ______________. A positive electron is a ____________________.	
2. After Stephen ___________ showed that metals conduct electricity (1666), C.F. de C.Du Fay in 1734 suggested that there were two types of electricity: ____________ if you rubbed glass and ______________ if you rubbed resin. It was Benjamin ______________ who ended this nonsense by recognizing that there ___________ and ____________ poles in electrical phenomena.	1. atom neutrons electrons protons positron
3. After von Kleist produced the condenser, van ___________ produced the __________jar. Until Volta explained Luigi Galvani's 'muscle energy' as battery action, the Leyden jar was the only source of ____________ scientists could control. Then water was decomposed to hydrogen and oxygen by ____________ and ____________. Berzelius and Hisinger in 1803 found that salts are decomposed during electrolysis into _______ at the negative pole and acids at the ______________ pole.	2. Gray vitreous resinous Franklin positive negative
4. At the Royal Institution in London _____________ produced a giant battery of over 250 metallic plates. He was first to electrolyze _________solids. He found the reactive metals __________ and __________. He went on to isolate Ba, _________; Mg, _________; Ca, ___________ and Sr, __________. Davy's most important find was Michael ________________.	3. Musschenbuck Leyden electricity Nicholson Carlisle bases positive
	4. Davy fused potassium sodium barium magnesium calcium strontium Faraday

5. Faraday discovered the Laws of ______________ and he explained electromagnetic _____________. Faraday asked William ___________ to find terminoligy for electrochemistry. The terms __________, ___________, __________, ___________, and ______________, were suggested.	
6. Although best known in organic chemistry _____________ developed the hypothesis that all atomic weights were whole numbers multiplied by the atomic weight of hydrogen. Thus if hydrogen were 1, then oxygen would be ________ and sodium __________. How many protons in the oxygen atom? ______________ How many in sodium? _________ Why is the atomic weight not equal to the number of protons? _______________.	5. Electrolysis induction Whewell electrode anode cathode ion cation anion
7. Compounds of similar composition crystallize together because of their similar ________________. This concept was discovered by ____________ in 1819. The phenomenon is called ______________. The Swedish chemist ___________ put Mitscherlich's notion to work in establishing atomic weights.	6. Prout sixteen (16) twenty three (23) eight (8) eleven (11) Atomic weight equals the number of particles in the nucleus.
8. In 1858, _____________ discovered the significance of Avogadro's ideas: "All gases, under the same conditions of __________and __________ contain the same number of molecules". Today we used _____________ name when we speak of the number of atoms or molecules present in an amount of substance that has a _________ respectively equal to its ________or ____________ weight in grams.	7. design (geometry) Mitscherlich isomorphism Berzelius
	8. Canizzaro temperature pressure Avogadro's mass atomic molecular

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9. Early work on the rare earths (Lanthanide series) was conducted by Gadolin, __________ and __________. The rest of the lanthanide metals were discovered by Welsback. Bunsen and Kirchoff collaborated in the 1850's to develop __________ analysis, a tool of modern analytical chemistry. Basically, each ______ has characteristic spectral _________ that are not affected by the presence of other _________. Bunsen and associates used this new technique to discover _________ (1860) and ___________ (1861).

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10. One of the earlist attempts at classification was that of Dobereiner who grouped members according to ____________ chemistry. Since usually there were three per group, he called them _____________. Can you list the triads in their groups? _____________; ___________; ___________; and ___________. Chancourtois developed the ___________ helix; Newlands arranged elements in groups of _________ to develop his "Law of __________". Almost simultaneously two chemists developed the Periodic ___________; the German Luther ___________ and the Russion D.I. ______________.

9. Mosander
Berzelius
spectroscopic
element
lines
elements
cesium
rubidium

---

11. There are four commonly used metals which are scarce, in relation to their use. Their symbols are Cu, Pb, Zn, and Sn..What are they? _____, _________, _________, and ____________.

10. similar
T triads
R Cl, Br, I
I Ca, Sr, Ba
A S, Se, Te
D Fe, Co, Mn
S Telluric
eight (8)
Octaves
Table
Meyer
Mendeleev

---

11. copper
lead
zinc
tin

12. Davis lists certain uncommon metals which are scarce in relation to their use. They are: Hg, Cd, Se, Ce, Sb, Bi, Au, Ag, (other noble metals), Ge, Be, and Pt - group. What are the names which match these symbols?

_______, ________, _______, _________, ____________.
_______, ________, _________, _________, ____________,
and __________.

12. mercury
cadmium
selenium
cesium
antimony
bismuth
gold
silver
germanium
beryllium
platinum

13. Certain metals are 'additives' to special steels. Name them and give their symbols.

13. Mn - manganese
Cr - chromium
Ni - nickel
Mo - molybdenum
W - tungsten
Ta - tantalum
V - vanadium
Co - cobalt
Nb - niobium
Ti - titanium

TM-1 ATOMIC THEORY
PACKET #3 - SELF - CORRECTING QUIZ

PLACE YOUR ANSWERS IN THE SPACES PROVIDED.

1. The minerals which support our whole economy and are abundant in relation to need are the ________________ materials.

2. Some materials are __________ in nature but, compared to that abundance little used.....these are the ____________________ materials.

3. Alunite, leucite, and feldspar are possible sources of ______________.

4. Lithium, cesium, hafnium, rhenium are four of the ten elements considered to be _______________________.

5. In the crust of the earth the most abundant element is ______________.

6. If all the universe is considered, and not just earth, the most abundant elements are _______________ and ______________.

7. The unit which expresses the abundance of an element based upon average crustal availability is named after _______________, a famous geochemist.

8. Lecoq de Bosidran discovered the element predicted by Mendeleev, _______________.

9. Winckler discovered the missing eka-silicon now called ________________.

10. The element polonium is the element div-tellurium predicted by __________.

11. "The atomic weight of an element may sometimes be amended by knowledge of the _______________ elements." (Mendeleev)

12. An unpaired electron tends to pair with any other electron to form _______________ radicals. Usually this causes the moiety to be _______________.

13. Sulfur forms a whole series of acids by replacing oxygen in other acids. The prefix used is __________ or ___________.

14. Elements whose nuclei have the same number of protons have practically identical properties regardless of the number of _______________. Although these forms differ in mass they have the same chemistry and are termed ________________________.

15. Tritium and deuterium are _________________ of hydrogen.

16. Inert elements are placed in the _______________ Group in the Periodic Table.

17. The _______________________ variation in the properties of the elements with increase in their masses is due to _________________ similarity in structure of their ______________________________.

18. Johann Joachim Becker and Georg Ernst ____________________developed the false ____________________Theory which held sway until the end of the eighteenth century.

19. In 1718 Etienne-Francois Geoffrey developed his Table of ____________________ which was an attempt to produce a ____________________Table.

20. The most famous Swedish master chemist was ____________________.

21. Carl Wilhelm ____________________, around 1750, worked on gases, manganese, molybdenum and discovered hydrofluoric acid.

22. Stephen Hales collected gases he produced chemically over water thereby inventing the ____________________trough.

23. Joseph ____________________, invented 'soda water', nitric oxide, and a gas measuring tube we now call a ____________________.

24. In 1914 Kurhakov suggested that alloys of indefinite composition be called ____________________-ides after the French chemist of similar name, while ordinary compounds be called daltonides after John ____________________.

25. The Dulong-Petit law states that the product of ____________________number and ____________________heat for an element is constant.

26. Mitscherlich in 1820 announced the law of ____________________which states that when two substances crystallize in similar forms they have ____________________formulae.

TM-1 ATOMIC THEORY
PACKET #1, 2 & 3   HISTORICAL REVIEW QUIZ

FILL-IN-THE-BLANKS IN THE SPACE PROVIDED.

1. Lavoisier's teacher was G.F. _______________ who introduced the name ____________________ for alkali hydroxides.

2. Rouelle recognized that acids and _______________ react to form stable salts and ________________________.

3. Rouelle recognized that salts could be acid, ______________ or basic.

4. Van Helmont discovered a 'gas _______________' which Black rediscovered when he heated 'calcined magnesia' (magnesium carbonate). This gas he called 'fixed ____________'; we call it carbon __________________.

5. The concept of specific _____________________ and latent heat were developed by Black.

6. Three chemists discovered the gas which makes up 78% of our normal atmosphere. The gas is ____________________. The chemists are Black's student, ______________, the ENglishman _________________ and the Swede ________________.

7. Van Helmont discovered 'gas sylvestre' in the 'wild spirit' we now call ______________________.

8. In DeRerum Natura _______________________explained the Epicurean version of the atomic ideas of Demokritos.

9. The 'Torr' is a measure of pressure named after the scientist who invented the barometer, Evangelista ___________________________.

10. When metals were heated in air a heavier substance was formed which the Phlogiston's called ________________, (We now know it was an oxide).

11. Robert _______________tried to burn sulfur in a vacuum...It did not burn but melted. He had proved that ______________ was required for burning.

12. Glauber was first to recognize that ______________ were made in two parts, one coming from acid and the other from a metal oxide.

13. Glauber discovered ______________decomposition, a process by which neutral salts could react to produce new salts.

14. The terminology of 'love' and 'hate' used by Glauber was that of __________ __________2100 years before. But, when the Greeks thought these two were physical bodies, Glauber thought of these as ____________________________.

TM-1 ATOMIC THEORY
PACKET #1. 2 7 3 HISTORICAL REVIEW QUIZ (cont.)

---

15. The 'willow-tree' experiment of Cursa was repeated by Jan Baptiste Van ________________ as an example of ____________________ chemistry.

16. The mass of a proton is about ___________ times that of an electron.

17. Mesons which are heavier than protons are called _________________.

18. The positively charged electron is the ______________________.

19. Brunschwygk used a conical air-cooled alembic (a Rosenhut) to produce plant essences by the method we call ____________________________.

20. Basil Valentine wrote the Triumphal Chariot of ______________________, in 1604, the first chemical monograph on a single element.

21. Zinc, cobalt, and bismuth were first discussed by Georgius _______________ in his text. _________ _________ __________________.

NAME: ______________________________

DATE: ______________________________

HAND IN TO INSTRUCTOR FOR HIS EVALUATION.

TM-1 ATOMIC THEORY
PACKET #4 - #831 - SELF - QUIZZES

Section I:

Using the periodic table write the atomic weights of following elements to the nearest 0.1 a.m.u.

1. Magnesium (Mg) ______________________
2. Manganese (Mn) ______________________
3. Silicon (Si) ______________________
4. Lithium (Li) ______________________
5. Zinc (Zn) ______________________

When you have completed your answers, restart the tape and advance to Frame 9.

Section 2:

Calculate the molecular weights of the following molecules. Use the periodic table to obtain the atomic weights of the elements.

1. Calcium Carbonate ($CaCO_3$) ______________________
2. Nitric Acid (HNO_3) ______________________
3. Sodium Chloride (NaCl) ______________________
4. Acetic Acid (CH_3CO_2H) ______________________
5. Sucrose ($C_{12}H_{22}O_{11}$) ______________________
6. Nitrogen (N_2) ______________________

When you have completed your answers, restart the tape and advance to Frame 14.

Section 3 - Part 1:

Calculate the weight of 1 mole of the following elements or compounds. Use the periodic table to obtain atomic weights.

1. Water (H_2O) ______________________
2. Sodium (Na) ______________________
3. Sucrose ($C_{12}H_{22}O_{11}$) ______________________
4. Calcium Carbonate ($CaCO_3$) ______________________

Section 3 - Part 1 (cont.):

5. Sodium Chloride (NaCl) ____________________

6. Benzene (C_6H_6) ____________________

7. Hydrochloric Acid (HCl) ____________________

Part 2:

1. How many atoms in 23,0g Sodium? ____________________

2. How many molecules in 78.0 grams of Benzene? ____________________

3. How many molecules in 18.0g Water? ____________________

When you have completed your answers, restart the tape and advance to Frame 20.

Section 4:

Calculate the weight in grams, given the number of moles of the following compounds or elements.

1. 2.0 moles of Water (H_2O) ____________________

2. 2.0 moles of Nitric Acid (HNO_3) ____________________

3. 2.0 moles of Magnesium (Mg) ____________________

4. 1.5 moles of Methane (CH_4) ____________________

5. 1.5 moles of Carbon Dioxide (CO_2) ____________________

6. 5 moles of Benzene (C_6H_6) (Mol. wt. = 78.0) ____________________

7. 0.2 moles of Glucose (C_6H_6) (Mol. wt. = 180.0) ____________________

When you have completed your answers, restart the tape and advance to Frame 22.

Section 5:

Calculate from the grams given the number of moles in the following compounds.

1. 3600 grams of H_2O (mol. wt. 18.0) ____________________

2. 960 grams of Methane (mol. wt. 16.0) ____________________

3. 315 grams of Nitric Acid (mol. wt. 63.0) ____________________

Section 5 (cont.)

4. 6 grams of Acetic Acid (mol. wt. 60.0) ____________________

When you have completed your answers, restart the tape and advance to Frame 24.

TM-1 ATOMIC THEORY
PACKET #4 - #831 FINAL REVIEW EXERCISE -- When finished hand in to instructor for his evaluation.

1. Using your periodic table, find the atomic weights of the following elements.

A. Carbon ____________________

B. Nitrogen ____________________

C. Hydrogen ____________________

D. Oxygen ____________________

E. Potassium ____________________

F. Iodine ____________________

2. Calculate the molecular weight of these molecules.

A. NH_3 - Ammonia ____________________

B. KI - Potassium Iodide ____________________

C. O_2 - Oxygen ____________________

D. CO - Carbon Monoxide ____________________

E. C_2H_2 - Ethane ____________________

3. Calculate the weight in grams of the following:

A. 1 mole of Ammonia molecules (NH_3) ____________

B. 2 moles of Oxygen molecules (O_2) ____________

C. 0.1 moles of CO molecules ____________

4. How many moles of atoms or molecules are there in the weight of these substances?

A. 117.3 grams of Potassium (K)

B. 2.8 grams of Ethane (C_6H_6)

C. 85 grams of Ammonia (NH_3)

D. 320 grams of Oxygen molecules (O_2)

NAME: __________________________

DATE: __________________________

TN-1 ATOMIC THEORY PACKET #4 - #831 - SELF QUIZ

Listen to tape and look at slides and when finished with Section I answer the following questions.

1. The mass and positive charge of an atom is concentrated in the ______________.

2. The __________ is a positively charged atomic particle which has a mass of ____________________ amu and a charge of ______________________.

3. The negatively charged particle, the ________________, is located ___________________ the nucleus of the atom.

4. If an atom contains 12 positive charges it will contain ________________ negatively charged particles.

5. The neutral atomic particles, the _____________, have a mass of _____________ and are located in the ________________of the atom.

6. Chlorine appears on the periodic table as:

17
Chlorine
Cl
35.453

This indicates that chlorine has an atomic number of _____________ and an atomic mass of ________________ amu.

TRUE OR FALSE

7. ________ All atoms of a given element contain the same number of positive charges.

8. ________ The nucelus of an atom occupies only about 1/1000th of the volume of the atom.

9. ________ The atomic number of an element indicates the number of neutrons in the nucleus.

10. ________ The atomic mass of the element indicates the number of neutrons in the atom's nucleus.

11. ________ The entire negative charge of the atom is outside the nucleus.

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 10.

SECTION 2
TRUE OR FALSE

1. ________ Each orbital can accommodate a maximum of two electrons.

SECTION 2

TRUE OR FALSE - (Cont.)

2. __________ Every atom has only one S type orbital

3. __________ In the second and all higher energy levels there are three P type orbitals.

4. __________ The lowest energy level can accommodate only two electrons.

5. The third energy level has ______________s orbital(s), __________p orbital(s), and ____________d orbital(s).

6. There is a maximum of ____________ electrons in the first energy level, ___________ electrons in the second energy level and ______________ in the third energy level.

7. The ________ type orbitals are spherical in shape and the ________ orbitals are 'dumb-bell' shaped.

8. The symbol $3d^6$ indicates that there are ________________ electrons in ___________ type orbitals in the ____________ energy level.

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 27.

SECTION 3

Use the orbital energy diagram on the following page to write the electronic configuration for elements 11 through 18.

ATOMIC #

11 Sodium ____________________________________

12 Magnesium _________________________________

13 Aluminum __________________________________

14 Silicon ___________________________________

15 Phosphorous _______________________________

16 Sulphur ___________________________________

17 Chlorine __________________________________

18 Argon _____________________________________

WHEN YOU HAVE COMPLETED THIS EXERCISE, RESTART TAPE AND ADVANCE TO FRAME 32.

SECTION 4

USING SPECTROSCOPIC NOTATION, $(1s^2)$ $(2s^2)$ etc., write the electronic structure for the following elements. You may wish to make and use a memory aid. The number with each element is its atomic number.

Nickel (28) ____________________ Sodium (11) ____________________

Bromine (35) ____________________ Oxygen (8) ____________________

Iridium (77) ____________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 37.

REVIEW EXERCISE

WHEN FINISHED WITH THIS EXERCISE HAND INTO THE INSTRUCTOR FOR HIS EVALUATION.

1. The symbol for aluminum on the periodic chart is: ____________________

2. Draw an approximate picture of our conception of a helium atom.

3. Write down the maximun possible number of each kind of electron in the major energy levels 1 - 4. Give the maximum number of electrons of all kinds in each of the major energy levels 1 - 4.

MAJOR ENERGY LEVEL	'S' ELECTRONS	'P' ELECTRONS	'D' ELECTRONS	'F' ELECTRONS	TOTAL
1					
2					
3					
4					

---

4. Draw and show the orientation in space of 'S' amd 'P' type electron orbitals.

5. What is the atomic number of the atom which has the electron configuration:

   $(1s)^2$ $(2s)^2$ $(2p)6$ $(3s)^2$ $(3p)^6$ $(4s)^1$? ______________________

6. What is the atomic number of an atom whose electron configuration is:

   $(1s)^2$ $(2s)^2$ $(2p)^6$ $(3s)^2$ $(3p)^6$ $(3d)^{10}$ $(4s)^2$ $(4p)^6$ $(4d)^2$ $(5s)^2$?

   ______________________.

7. What is the electronic structure of oxygen? Use electronic configuration notation. ______________________

8. What is the structure of phosphorus? Use electronic configuration notation. ______________________

9. Find the atomic number of beryllium from the periodic chart. Write out the electron configuration for beryllium using the spectroscopic notation.

   ATOMIC NUMBER ______________________

   ELECTONIC CONFIGURATION OF BERYLLIUM ______________________

10. Write out the electron configuration for argon (Ar, atomic #18)

    ____

11. Write out the electron configuration for rhenium (Re, atomic #75). How many unpaired electrons does rhenium have?

    ____

    ______________________.

STUDENT NAME: ______________________

DATE: ______________________

TM-1 ATOMIC THEORY
PACKET #5 - PROGRAMMED TEXT MATERIAL

1. Matter is anything that occupies space and has ______________; energy is the power or __________ to do work.

2. The statement that matter can neither be created nor _________ is referred to as the Law of Conservation of __________. The statement that energy can neither be _________ nor _________ is referred to as the ________ of _________ of ____________.

1. weight (mass)
ability

3. Under extraordinary conditions, however, the Laws of _________________ are not true, for matter can be converted into _______________ and vice versa - an event expressed by the Einstein equation $E = mc^2$, (E stands for energy; m, mass; and c, speed of light).

2. destroyed
Matter
created
destroyed
Law
Conservation
Energy

4. Strict accuracy, therefore, calls for combining the two laws into a single statement; THE TOTAL AMOUNT of matter and energy together in the universe cannot be increased or ______________; or we could say that the total amount of matter and energy together is _______________________.

3. Conservation
energy

5. A physical change is one that does not result in a new kind of substance, water is __________ whether it be steam or ice, and glass is __________ whether it be a window or smashed.

4. decreased
constant

6. A chemical change does result in a __________ kind of substance. The rusting of iron, the burning of paper, the souring of milk are all ____________ changes.

5. water
glass

7. By ____________ properties we refer to those attributes of a substance that can be determined without changing the substance into some __________ kind of matter. Color, taste, odor, boiling point, and so forth, are all _______________________.

6. new
chemical

7. physical
new
physical

8. ______________ properties are those characteristics of substances that relate to ______________ or lack of action with other substances. That iron rusts and gold does not rust; or that sodium reacts with chlorine to form salt are examples of ______________ properties.	
9. Matter may exist in three forms: ______________, liquid or ______________. Water may exist as the liquid, ______________, ice or gas, ______________. The difference of forms is a ______________ rather than chemical state; being the motion of a sustance's molecules. The solid state has the least ______________ and the most motion is in the ______________ state. To change a liquid to a solid heat must be ______________; to change a liquid to a ______________, ______________ must be added.	8. Chemical reaction chemical
10. There are three kinds of matter: elements, ______________ and ______________. ______________ are the basic 'building blocks' of all matter. There are ______________ known elements. Some elements (P & S, i.e.) exist in two or more different forms with different properties. This is called ______________; the forms themselves are called ______________.	9. solid gas solid steam physical energy gaseous subtracted gas energy (heat)
11. A ______________ is formed when two or more ______________ chemically unite, each losing its identity in the process. The Law of Definite Proportions states that when elements combine to form a ______________ they always do so in a definite proportion by ______________.	10. compounds mixtures Elements 103 (more to come) allotropism allotropes
12. A ______________ is any conceivable combination of elements and compounds. There is not definite ______________ by weight. It could be a combination of elements, compounds, or both.	11. compound elements compound weight
	12. mixture proportion

13. Mixtures are not ____________combined and because of this they can be easily ___________. When boiled a salt solution gives off _____________ and leaves the _______________, as a residue in the evaporating dish.	
14. Density and specific gravity are ________________ properties; they are commonly used in chemistry. ________________ is the weight or mass per unit volume; by _____________ weight by volume we get the density of a substance. Density is expressed as grams per milliliter (g/ml). If 10 ml of a liquid weighs 20 grams, what is its density? ______________ A piece of metal weighing 60 grams is dropped into a graduated cylinder containing water which rises from 40 ml to 55 ml. The metal has a mass of ________________, a volume of _____________ and a density of __________.	13. CHEMICALLY separated steam salt
15. Specific gravity is the weight of a substance compared to the weight of water. To find the specific gravity of a substance we would weigh the substance and divide this by the ___________ of an equal _________ of _____________. 1 ml of water weighs 1 gram. If 40 ml of a liquid weighs 100 grams what is its specific gravity? _____________ Because 1 ml of water weighs 1 gr. the __________ and ______________ are numerically equal. If 50 ml of a liquid weighs 100 grams, it has a density of ___________ and a spcific gravity of ________.	14. physical Density dividing 2 60 15 ml 4 g/ml
16. Density is grams per _________; specific gravity tells us how much ____________ or lighter a substance is than _____________. Any substance heavier than water has a specific gravity greater than ____________; and a substance _______________ than water has a specific gravity _____________ than 1.	15. weight volume water 2.5 density specific gravity two (2) two (2)
	16. ml heavier water 1 lighter less

TM-1 ATOMIC THEORY
PACKET #5 (cont.)

17. ______________ is a form of ____________. Two types of units are used to measure heat: ________ units and __________ units. The quantity of heat is measured in units of ______________, ____________ and the British Thermal Unit (_________). The intensity of ___________ is measured by a ______________ and expressed in degrees.	
18. On a Celsius scale water freezes at 0°C and boils at 100°C. On a Fahrenheit scale water freezes at 32°F and boils at ______°F. 1 C is equal to _________ degrees F. To convert from one scale to another what formula is used? _______________	17. Heat energy quantity intensity calories (or Kilocalories) B.T.U.'s heat thermometer
19. A calorie is the quantity of ___________ required to raise the temperature of one gram of water ______ degree C. A _______________ is the _____________ of heat required to change the temperature of _________ grams of water _________ degree °C. BTU is the quantity of heat required to raise the ___________ of one pound of water, one degree °F.	18. 212 1.8 (9/5) $F = 1.8\ C + 32$ $C = \frac{F - 32}{1.8}$
	19. heat one kilocalorie quantity 1000 one temperature

TM-1 ATOMIC THEORY
PACKET #6 - PROGRAMMED REVIEW

The following programmed materials concern the mechanics of elementary chemistry. It is essential to understand atomic structure, valence, molecules and formulas. You will have to use the accompanying table to answer and understand some of the questions.

---

1. For maximum stability atoms atrive for an outer shell containing the maximum number of ____________, with the exception of the K shell, this number is ________________.

---

2. Atoms attain this end by reacting with each other in one of two ways: electrovalence, the loss of _____________, or covalance the sharing 6f ________.

1. electrons
   eight

---

3. ____________________ is strongly displayed by atoms with only one or two _______________ to gain or _________________.

2. electrons
   electrons

---

4. For example, when the elements sodium and chlorine are brought together a reaction ensues to form salt. Each _____________ atom _________ one electron and each chlorine atom ___________ one _____________. As a result, the atoms have the __________number of ____________ in their outer ________________.

3. Electrovalence
   electrons
   lose

---

5. Electrically speaking, a drastic change has occurred, for the atoms are no longer neutral but ___________________.

4. sodium
   losing
   gaining
   electron
   maximum
   electrons
   shell

---

6. The sodium atoms have a positive charge of _____1, (Na^+), and the chlorine atoms have a ________ charge of ________1, (Cl^-). We no longer have atoms, for atoms are _______; what we have are charged atoms or ________. Since like electrical charges repel and unlike charges ______, we may visualize a crystal of salt as being composed of ______ different kinds of ions, Na^+ and Cl^- held together by electrostatic forces.

5. charged

---

6. plus
   negative
   minus
   neutral
   ions
   attract
   two

7. In covalence, atoms attain a full __________ shell by __________ electrons. In the formation of ammonia, hydrogen attains the full number of ______________ electrons in its outer shell, and nitrogen attains the full number of ____________ electrons in its outer shell. Since no electrons are either gained nor __________, but only shared, no charged atoms or ____________ are involved. Draw what happens and hand into instructor when packet is completed.	
8. Valence is concerned with the combining power of __________ and explains why certain elements combine with other elements to form _____________. Compounds formed by electrovalence are composed of __________; those formed via covalence are not ______________.	7. outer sharing two eight lost ions
9. Calcium has a charge of +2 because it has two more protons or ________ charges than ________ or negative charges. An element with a valence of -2 is composed of atoms that during a reaction _______ two ____________. The reason that an element forms ions with a negative charge or two is because there are ________ more _________ than _____________.	8. atoms compounds ions ionic (electrovalent)
10. An atom with a covalence of two shares with another __________ one pair of ____________. This shared pair is called a ________. An atom with a covalence of two __________ two pairs of __________.	9. positive electrons gain electrons two electrons protons
11. A _____________ is the smallest possible particle of a compound. The smallest possible particle of salt wouldcontain one ion of ________ and one ion of ___________. A _________ of salt can be expressed as NaCl. The Na stands for ________ atom or ion of sodium and the Cl for ________ atom or ion of ________.	10. atom electrons bond shares electrons
	11. molecule sodium chlorine molecule one one chlorine

12. Carbon dioxide is expressed as CO_2, which means that every ________ of this compound is composed of ______ ______ of ________ and _____ atoms of _________.	
13. A _________ is a symbolic statement of the kind and number of ions present in a _________. The valences of the elements tell us how to write a ______________.	12. molecule one atom carbon two oxygen
14. The formula for salt is NaCl because one electron ___________ by the sodium atom required only _____ atom of chlorine to accept it.	13. formula molecule formula
15. The formula for magnesium fluoride is MgF_2 because the magnesium atom loses ________ electrons and an atom of fluorine accepts only ________ electron and this means that _________ atoms of _________ are needed to accept the __________ electrons lost by each atom of _______________.	14. lost one
16. One thinks of _________ electrons when referring to covalent compounds. An atom such as nitrogen can share three pairs of electrons abd requires ________ atoms of hydrogen because an atom of hydrogen can share only ______ ________.	15. two one two fluorine two magnesium
17. The formula for ammonia is NH_3. This means that every _________ of this substance contains one atom of _________ and ________ atoms of _____________.	16. shared three one pair
	17. molecule nitrogen three hydrogen

18. In writing the ________ for a __________ all we need do is balance the valences. The formula for calcium chloride is $CaCl_2$ because calcium has a valence of ______ and chlorine a valence of ________. We need ________ atoms of chlorine to balance one atom of calcium. The formula for calcium oxide is CaO because ______, the valence of calcium, balances ______, the valence of __________.

---

19. Write the formulas for the following compounds; potassium oxide, ______; magnesium iodide, _______; calcium fluoride, ________; barium iodide, _________ lead chloride, _________; aluminum bromide, ________; and aluminum oxide, _________.

18. formula
compound
2
1
two
2
2
oxygen

---

20. If you had trouble with the last formula, note that 3--the valence of __________ -- times 2-- its subscript--equals or balances 2--the valence of _________ --times 3, its subscript.

19. K_2O
MgO
CaF_2
BaI_2
$PbCl_2$
$AlBr_3$
Al_2O_3

---

21. Some elements have more than one __________. There are two oxides of sulfur -- SO_2, _________ and SO_3, sulfur _________. Oxygen has a valence of ______, and since there are ________ atoms of oxygen in SO_2, sulfur has a valence of ________ to balance two times ________. Sulfur in the compound SO_3 has a valence of __________.

20. aluminum
oxygen

---

21. valence
sulfur dioxide
trioxide
2
two
4
two
6

22. The prefix of an oxide indicates the particular valence involved -- 'di', ______, etc. In metals the suffix 'ous' and suffix 'ic' represent the lowest and ____________ valences, respectively. Iron forms two chlorides, ferrous chloride ($FeCl_2$) and __________ chloride, (__________). This is more than purely academic, _________ chloride was formerly used as a laxative, mercuric chloride (________) is a deadly poison.	
23. A ___________ is defined as a group of atoms acting in most chemical reactions as a unit. For formula writing a radical is a single charged particle or ________. NH^+ has a charge of _______ one and a valence of _______. SO_4^{2-} has a charge of _________ two and a valence of _________. The formula for barium sulfate is $BaSO_4$ because both barium and sulfate have valences of ______________.	22. tri- highest ferric $FeCl_3$ mercurous $HgCl_2$
24. The formula for sodium sulfate is __________ because two times one equals two. The formula, $AlOH_3$, for the compound aluminum hydroxide is WRONG because OH is a ___________ and must be treated as a unit. This wrong formula says that there are three hydrogens but only one _________. When a radical is combined with an element with a valence of ________ than one, parentheses must be used. Thus the formula of aluminum hydroxide is _______________.	23. radical ion plus 1 minus 2 two
	24. Na_2SO_4 radical oxygen more $Al(OH)_3$

25. The following is a list of compounds and their formulas. Fill in the formulas.

ammonium ortho phosphate __________
aluminum sulfate __________
aluminum nitrate __________
calcium sulfite __________
magnesium hydroxide __________
potassium bicarbonate __________
mercurous nitrite __________
ferrous sulfite __________
ferric sulfate __________
cuprous carbonate __________

25. $(NH_4)_3PO_4$
$Al_2(SO_4)_3$
$Al(NO_3)_3$
$CaSO_3$
$Mg(OH)_2$
$KHCO_3$
$HgNO_2$
$FeSO_3$
$Fe_2(SO_4)_3$
Cu_2CO_3

TABLE OF COMMON ELEMENTS AND RADICALS

ELECTROVALENT

METALS

Aluminum	3	(Al^{3+})
Barium	2	(Ba^{2+})
Bismuth	3,5	(Bi^{3+}) (Bi^{4+})
Calcium	2	(Ca^{2+})
Copper	1,2	(Cu^{2+})
Hydrogen	1	(H^{-})
Iron	2,3	(Fe^{2+}) (Fe^{3+})
Lead	2	(Pb^{2+})
Magnesium	2	(Mg^{2+})
Mercury	1,2	(Hg^{+}) (Hg^{2+})
Nickel	2	(Ni^{2+})
Potassium	1	(K^{+})
Silver	1	(Ag^{+})
Sodium	1	(Na^{+})
Tin	2,4	(Sn^{2+}) (Sn^{4+})
Zinc	2	(Zn^{2+})

NONMENTALS

Bromine		(Br^{-})
Chlorine	1	(Cl^{-})
Fluorine	1	(F^{-})

ELECTROVALENT

RADICALS

Ammonium	1	(NH_4^{+})
Bicarbonate	1	(HCO_3^{-})
Carbonate	2	(CO_3^{2-})
Chlorate	1	(ClO_3^{-})
Hydroxyl	1	(OH^{-})
Nitrate	1	(NO_3^{-})
Nitrite	1	(NO_2^{-})
Phosphate	3	(PO_4^{3-})
Sulfate	2	(SO_4^{2-})
Sulfite	2	(SO_3^{2-})

COVALENT

Carbon	4
Hydrogen	1
Nitrogen	1,2,3,4,5
Oxygen	2
Phosphorus	3,5
Sulfur	4,6

Iodine	1	I^-
Oxygen	2	O^{2-}
Sulfur	2	S^{2-}

TM-1 END OF MODULE TEST

MATCHING

---

1. ______ aqua regia
2. ______ calx
3. ______ kalium
4. ______ muriatic acid
5. ______ eka-silicon
6. ______ lignite
7. ______ columbium
8. ______ hydrogen
9. ______ iron
10. ______ silicon

A. Hydrochloric acid

B. most abundant element in universe

C. lime, earthy oxide of any other metal

D. niobium

E. chief of the triad with CO & N

F. potassium

G. nitric & hydrochloric acids

H. coal

I. carbon family

J. germanium

WRITE FORMULAS FOR:

ammonium hydroxide ______________

cuprous nitrate ______________

ferric chloride ______________

mercury (I) nntrite ______________

lanthanum nitrite ______________

WRITE NAMES FOR:

$(NH_4)_2MoO_4$ ______________

$KHSO_3$ ______________

$(Ba)_3(PO_4)_2$ ______________

$CaSeO_4$ ______________

$FeSO_4$ ______________

WRITE SYMBOLS FOR:

mercury ______________

lead ______________

ytterbium ______________

holmium ______________

hydroxyl ______________

sulfate ______________

GIVE NAME OF:

Sb ______________

Bi ______________

Se ______________

Au ______________

Ag ______________

W ______________

TM-1 END OF MODULE TEST

WRITE SYMBOLS FOR (cont.)		GIVE NAME OF (cont.)	
potassium	____________	Y	____________
technetium	____________	Ac	____________
fluorine	____________	Tm	____________
radium	____________	P	____________

DRAW COMPLETE spdf nomenclature for:

HYDROGEN ________________________________

CARBON ________________________________

CALCIUM ________________________________

POTASSIUM ________________________________

ALUMINUM ________________________________

ZINC ________________________________

HELIUM ________________________________

SULFUR ________________________________

GERMANIUM ________________________________

BERYLLIUM ________________________________

NAME: ____________________

DATE COMPLETED: ____________________

GRADE: ____________________

TM-2 ATOMIC STRUCTURE, THE PERIODIC TABLE AND CHEMICAL NOMENCLATURE

PURPOSE:

To aid the student in developing comprehension of the nature and geometry of atoms; the step-by-step construction of the Periodic Table; and the order and simplicity of the International Rules for naming inorganic chemicals.

MATERIALS:

1. American Chemical Society, Nomenclature of Inorganic Chemistry. Reprint #82 (paper) or latest reprint of these rules.
2. Kass, G. The Atom & the Chemical Bond. Programmed texts from W. A. Benjamin, Inc., Reading, Mass. Vol. I and Vol. II. Vol. III - Problems in Chemistry is also useful.
3. Communication Skills Corporation Slide-Tape Presentations

#852	Atomic Structure and the Periodic Table
#853	Electrical Forces within the Atom
#854	Classification of the Elements

Communication Skills Corporation, P. O. Box 684, Fairfield, Conn., 06430

4. A modern Periodic Table
5. Atom & Models Cassette, Canadian Broadcasting Co. The Center for Cassette Studies, Inc., 8110 Webb Ave., N. Hollywood, Cal.

OBJECTIVES: To enable the student to:

1. Compare schemes use by scientists to depict atoms and molecules.
2. Prepare and utilize atomic and molecular models.
3. Place elements in their correct position in atomic periods and families.
4. Understand the I.U.P. A.C. nomenclature system.
5. Manufacture a wall-sized periodic table.

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE

INSTRUCTION AND CHECKOFF SHEET *DATE STARTED:* ____________

INTRODUCTION:

Listen to tape Atoms and Models - TAKE NOTES.

Utilize Gerard Kass's Individual Study Booklets on THE ATOM & THE CHEMICAL BOND. TAKE SELF-QUIZZES.

Submit notes on tapes and self-quizzes to instructor.

DATE COMPLETED: ________________

INSTRUCTOR SIG.: ______________

PACKET #1 - Utilize CSC #852 ATOMIC STRUCTURE AND THE PERIODIC TABLE. Take Quiz and submit to instructor.

DATE COMPLETED: ________________

INSTRUCTOR SIG.: ________________

PACKET #2 - Utilize CSC #853 ELECTRICAL FORCES WITHIN ATOMS. Take Quiz and submit to instructor.

DATE COMPLETED: ________________

INSTRUCTOR SIG.: ________________

PACKET #3 - Utilize CSC #854 - CLASSIFICATION OF THE ELEMENTS. Take Quiz and submit to the instructor.

Reproduce the shapes in neat 3-D drawings of the s, p, d, and f orbital forms. (f orbitals are shown on sheet in this packet. Submit drawings to instructor.

DATE COMPLETED: ________________

INSTRUCTOR SIG.: ________________

PACKET #4-A -

Read pages 5523-5526 frim I.U.P.A.C. reprint and utilize programmed review after reading to test your knowledge.

PACKET #4-B

Utilize the Inorganic Nomenclature Programmed Aid and read the I.U.P.A.C. rules beginning on page 5526 "Formulas and Names of Compounds in General". Use this programmed review only after Inorganic Nomenclature is mastered.

Ask instructor for Quiz for Packet 4-A and 4-B.

TM-2
INSTRUCTION AND CHECKOFF SHEET (cont.)

QUIZ RESULTS: ____________

DATE COMPLETED: ____________

INSTRUCTOR SIG.: ____________

PACKET #5

REQUEST PACKET #5 INSTRUCTION SHEET FROM INSTRUCTOR. THIS IS INFORMATION ON REPRODUCING YOUR OWN PERIODIC TABLE. WHEN COMPLETE SUBMIT YOUR PERIODIC TABLE TO INSTRUCTOR.

DATE COMPLETED: ____________

INSTRUCTOR SIG.: ____________

WRITTEN EXAM ____________ MODULE COMPLETED ____________ INSTRUCTOR INITIALS ______

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE - #852
PACKET #1 - ATOMIC STRUCTURE AND THE PERIODIC TABLE - AN INTRODUCTION
SELF-QUIZZES.

SECTION ONE

TRUE OR FALSE

____________ 1. The elements are arranged on the modern periodic table chart on the basis of their atomic numbers.

____________ 2. All elements above 92 on the periodic are man-made.

____________ 3. The atomic number of ${}^{4}_{2}He$ is 4.

____________ 4. The number of protons equals the number of neutrons in a neutral atom.

____________ 5. There are 12 protons in ${}^{23}_{11}Na$.

____________ 6. There are 12 neutrons in ${}^{23}_{11}Na$.

____________ 7. There are 11 electrons in neutral ${}^{23}_{11}NA$.

____________ 8. The three naturally occuring isotopes of oxygen are ${}^{16}_{8}O$, ${}^{17}_{8}O$, and ${}^{19}_{8}O$.

____________ 9. ${}^{16}_{8}O$ is the most abundant isotope of oxygen.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 11.

SECTION TWO

YOU WILL NEED TO CONSULT A PERIODIC TABLE TO ANSWER THE QUESTIONS IN THIS SECTION.

1. List the elements in Group IIIA.

2. Which other "A" group has the same characteristics valence state as Group IIIA?

3. Write out the elements in Period 3, in order of increasing atomic number.

4. Write down the formulas you would expect for compounds of each of the Period 3 elements with hydrogen (hydrides).

SECTION TWO (cont.)

5. Argon boils at - 186° C. Xenon boils at - 107° C. What boiling point would you predict for krypton?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 23.

SECTION THREE

WRITE DOWN THE GENERALIZED OUTER ELECTRON STRUCTURE FOR ALL THE "A" GROUPS OF THE PERIODIC TABLE. INCLUDE THE STRUCTURE FOR GROUP "O", THE INERT GASES.

	OUTER ELECTRON STRUCTURE
IA	(CORE)
IIA	(CORE)
IIIA	(CORE)
IVA	(CORE)
VA	(CORE)
VIA	(CORE)
VIIA	(CORE)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 31.

SECTION FOUR

1. Write down the elements in the first TRANSITION SERIES in order of increasing atomic number. Which inner electron level is filling up this series?

2. Write down the elements in the first INNER TRANSITION SERIES in order of increasing atomic number. Which inner electron level is filling up in this series?

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE
PACKET #1 - 852 - FINAL EXERCISE

COMPLETE THE FOLLOWING:

1. The first periodic table was prepared by the Russian chemist Dmitri Mendeleyev. He arranged the elements in order of increasing __________ ______________.

2. The mass number of an atom is the total number of __________ and __________ in its nucleus.

3. The fundamental property of any atom is its __________ __________________.

4. The mass number of $^{18}_{8}O$ is _______ and its atomic number is ________________.

5. In the modern periodic table the elements are arranged in order of increasing ______________ ________________________.

6. A group in the periodic table is one of the ________________. The elements in a group have ________________ chemical properties and _________physical properties.

7. A period is one of the ______________ in the table. There are a total number of ___________________ in the table.

8. The elements at the beginning of a period are ______________; the elements at the end of the period are _____________________.

9. Group 0 contains six gases; they are: _____________, ______________, ___________, ______________, _______________, _________________. Chemically these gases are all ____________________.

10. Elements in the same group all have _______________ outer electron shells.

11. The electrons from the core underneath the outer electrons ________________ take part in chemical reactions.

12. The generalized outer electron structure $(ns)^2(np)^3$ is that of group ____________.

13. The generalized outer electron structure $(ns)^2$ is that of group _________________.

14. The generalized outer electron structure of $(ns)^2$ $(np)^6$ is that of group _________.

15. The electron level filling up in the second transition series is the ____________ level.

16. The electron level filling up in the second inner transition series is the ________________________level.

GIVE THE COMPLETED EXERCISE TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ____________________________

DATE: ____________________________

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE
PACKET #2 - CSC 853 - ELECTRICAL FORCES WITHIN ATOMS -- SELF QUIZZES

SECTION ONE

1. The listing for carbon in the Periodic table is: The atomic number of carbon is ____________. This indicates there are ____________ protons in the nucleus and there is the same number of _____________ ________________ outside the nucleus.

   6
   CARBON
   C
   12.011

2. The nuclei of atoms have ___________ charges.

3. The electrons of an atom each have a ___________ charge, and the protons each have a ______________ charge.

4. Electrons are attracted by __________ and _________ by other electrons.

5. If the magnitude of charge on two particles is increased the strength of electrical interaction between them)increases, decreases).

6. If the distance between two charged particles increases two times, the strength of the electrical interaction between them decreases _______ times.

7. If a glass rod is rubbed with silk, the rod gets a _______ charge and the silk a _____________ charge.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 12.

SECTION TWO

TRUE - FALSE

___________ 1. An electron in the second principle energy level ($n = 2$) of an atom is attracted by the nucleus less strongly than an electron in the first principle energy level ($n = 1$) of the same atom.

___________ 2. Ionization potential is the work needed to pull an electron off an isolated atom.

___________ 3. The first ionization potential of Barium (at. no. 56) is greater than that of Calcium (at. no. 20).

____________ 4. The effective nuclear charge experienced by each 2s electron of Beryllium (at. no. 4, electron structure $(1s)^2$ $(2s)^2$) is +2.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 22.

IT IS IMPORTANT TO NOTE THAT THERE IS AN ERROR IN THE SLIDES. SLIDE 25 shows the symbol for FLUORINE TO BE Fl - which is in error - the symbol for FLUORINE IS F.

SECTION THREE

TRUE - FALSE

____________ 1. In any period, the Group IIA elements have one more positive charge in the nuclei of their atoms than Group IA and so attract electrons more strongly.

____________ 2. Due to the regular increase in effective nuclear charge from left to right in any period there is a regular increase in the force with which the atoms' electrons are bound and, therefore, a decrease in atomic volume.

____________ 3. Calcium has 20 protons in it nucleus and 18 electrons in inner screening orbitals. The effective nuclear charge on the outermost electrons is + 18.

____________ 4. Calculate the effective nuclear charge on the outer level 3 electrons of all the elements in period 3.

Na __________, P __________, Mg __________, S __________,

Al __________, Cl __________, Si __________, Ar __________.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 27.

WHEN YOU HAVE FINISHED THE TAPE AND SLIDES, HAND IN THESE SELF QUIZZES AND REQUEST THE END OF PACKET QUIZ FROM YOUR INSTRUCTOR.

TM-2
PACKET #2 - END OF UNIT QUIZ

FILL IN THE CORRECT ANSWER - INCREASE, DECREASE OR REMAIN THE SAME.

1. If the number of neutrons in an atom increases, the attraction of the nucleus for the outer electrons ____________________.

2. If the distance between a proton and an electron is decreased, the attraction between them ____________________.

3. In Period 2, going from Fluorine (F) to Neon (Ne) the strength with which the outer electrons are attracted _____________, and so the atomic volume ____________________.

4. In Period 4, going from Potassium (K) to Calcium (Ca) the amount of inner electron shielding ____________________ and the nuclear attraction for the outermost electrons ____________________.

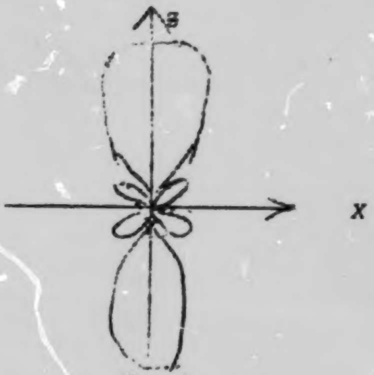
5. Going down a group of elements in the Periodic Table, the number of electrons in the outermost orbitals __________ so in any group the effective nuclear charge on the outer electrons __________________. But because the radius _____________ going down the group, the attraction for the outermost electrons ____________________.

WHEN YOU HAVE COMPLETED THIS EXERCISE, GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

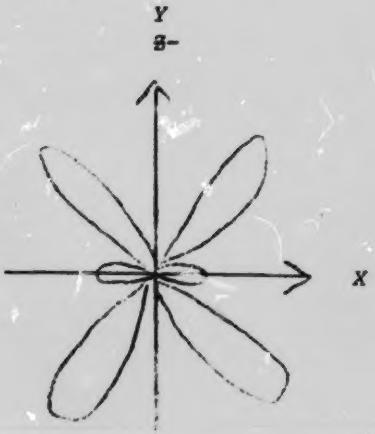
NAME: ____________________________

DATE: ____________________________

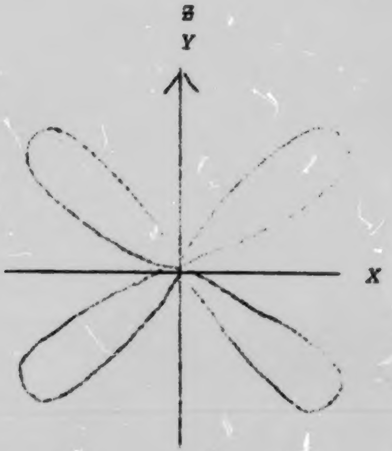
PACKET #3 - f-ORBITALS (THEORETICAL)



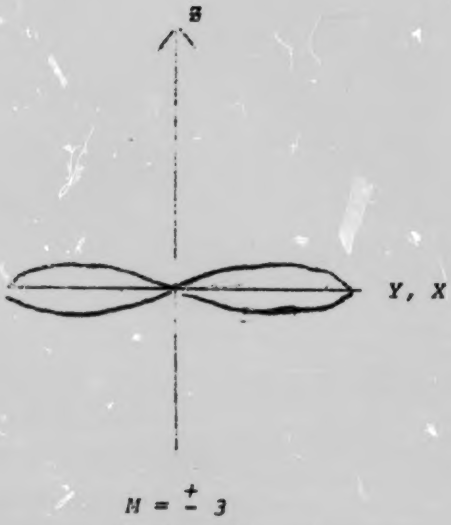
M = 0
(1 Form)



M = ± 1
(2 Forms)



M = ± 2
(2 Forms)



M = ± 3
(2 Forms)

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE.

PACKET #3 - CSC 854 - CLASSIFICATION OF THE ELEMENTS: METALS; NON-METALS; METALLOIDS - SELF QUIZZES

SECTION ONE

CONSULT A PERIODIC TABLE TO ANSWER THE FOLLOWING QUESTIONS.

TRUE - FALSE

________________ 1. All the elements in a given period have the same outer energy level.

________________ 2. P atoms have greater ionization energies than S. atoms.

________________ 3. It is more difficult to remove the first electron from an O atom than from a B atom.

________________ 4. The first element in each period has the lowest ionization energy of any element in that period.

________________ 5. The last element of a period is a noble gas with the highest ionization energy of any element in that period.

________________ 6. Be has a higher first ionization energy than B because the electron from Be must be removed from a filled 's' orbital.

________________ 7. O atoms have higher ionization energies than N atoms because of the greater positive charge on the oxygen nucleus.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 15.

SECTION TWO

TRUE - FALSE

________________ 1. The transition elements are those in which electrons are filling up the 'd' orbitals of the next to the outer energy level.

________________ 2. The ionization energy of transition series elements increases less from left to right than elements in the A-group of the same period.

________________ 3. In general, there is an increase in attraction for outer electrons from left to right within a period.

________________ 4. Ionization potential increases with increasing atomic number within a group of the periodic table.

________________ 5. *There is a special stability associated with half-filled or completely-filled electron orbitals.*

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 22.

HAND THESE SELF QUIZZES INTO YOUR INSTRUCTOR AND REQUEST THE END OF PACKET QUIZ.

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE

PACKET #3 - END OF UNIT QUIZ

TRUE - FALSE

1. ____________ Metals are elements with relatively weak attraction for their outer electrons.

2. ____________ The majority of elements have relatively strong attraction for their outer electrons.

3. ____________ On the periodic chart, the elements at the beginning of any period generally exhibit more metallic properties than the elements at the end of the same period.

4. ____________ All transition elements are metals.

5. ____________ The elements in group VIIA (the Halogens) increase in non-metallic property with increasing atomic number, i.e. I is more non-metallic than F.

6. ____________ Na is more metallic in nature than Rb.

7. ____________ Al is a better electrical conductor than S.

8. ____________ Mg loses electrons in chemical reactions, whereas O tends to gain electrons.

9. ____________ Electron affinity is the energy released when an electron is removed from a neutral atom to form an ion.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, GIVE THIS EXERCISE TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ____________________________

DATE: ____________________________

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE

PACKET #4-A Nomenclature of Inorganic Chemistry - Elements

Read pages 5523-5526 from I.U.P.A.C. reprint and utilize this programmed work to test your knowledge.

---

1. I.U.P.A.C. means? ____________ The official languages of the union are? ______________

2. The Commission's aim always has been to _______ rules which lead to _________ and _____________ names for as many __________ as possible.

1. International Union of Pure and Applied Chemistry

English, French

---

3. The symbols which you must memorize are listed in Table I. What element is often incorrectly (stubbornly) still called columbine? __________ What element has a German origin and is stubbornly called by a name not matching its symbol? ________________

2. produce
clear
acceptable
inorganic compounds

---

4. When ions are formed from copper. gold, iron, lead, silver, tin and tungsten they use what names? _________, _________, __________, _________, _________, _________, __________. What names are also associated with nitrogen and antimony? __________, ___________

3. niobium, Nb
tungsten, W should be wolfram

---

5. What problem exists with the name nickel?

4. cuprum
aurum
ferrum
plumbum
argentum
stunnum
wolfram
azote
stibium

---

6. How are isotopes of hydrogen named? __________ How are others named? ____________

5. in other languages niquel, nikkel..therefore use niccolum stem

---

6. only the isotopes of hydrogen have special names- deuterim, tritium (protium)
other isotopes are singly designated with nucleon numbers - O-18, P-32 etc.

PACKET #4A (cont.)

7. Can collective names be used? _______ What are F, Cl, Br, I, At; ___________. O, S, Se, Te, Po; ________. Li, Na, K, Rb, Cs, Fr; _________. Be, Ca thru'Ra; _________. He, Ne thru' Rn ___________? What elements are in the rare earths? _________. What are the elements Ce to Lu called? ___________.
NOTE: WATCH OUT FOR LANTHANUM SERIES (57-71) versus the LANTHANOIDS SERIES (58-71).

8. The elements following uranium are collectively called ___________. The series 89-103 is called the __________ series, while thse involving filling of a _________ shell are called the __________. The older term halogenide has been replaced with the term _________.
Why should lanthanide and actinide be avoided? ___________.
You will see the term metalloid used often, even in textbooks and by instructore. It is not an incorrect term. A non-metal is a non-metal; not a metalloid.

7. Yes
halogens,
chalogens
Alkali metals
alkaline earth metals
inert gases
Sc, Y and the series La to Lu inclusive
Lanthanoids

9. Draw a full page drawing of element 17 (on a kritter sheet), which is triply ionized, is diatomic, and has mass number 36. An example of how sulfur should look is given below.

$${}^{32}_{16}\mathrm{S}^{2+}_{2}$$

mass number		total change
	S	
atomic number		number of atoms

8. the transuranium elements
actinium
5f
actinoid
halide
could be confused with binary salt ending ide.
NOTE: You will see lanthanide and actinide used often (INCORRECTLY) in U. S. literature.

10. Isotopically labeled nitric acid is used employing tritium and nitrogen-15. What is the correct symbol?

9. Submit to instructor

10. ${}^{3}H{}^{15}NO_{3}$

PACKET #4A (cont.)

11. An open chain of sulfur atom is symbolically S_n and may be called ___________ sulfur. If it closed to a large ring it is called __________ sulfur. If it is composed of small rings of variable size the term _________ is preferred. If rings are 3, 4, 5, 6, 7, 8, or 9 the correct terms are: ___________________________________.

12. What do geologists use to denote such ring structures? ____________, ____________, ___________, __________,and ____________.

11. poly
catena
cyclo

cyclo-tri
tetra
penta
hexa
hepta
octa
nona
e.g. cyclopentantimony

12. ion
neso
phyllo
tecto
soro

NOW PROCEED TO PACKET #4-B

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE
PACKET #4-B - NOMENCLATURE OF INORGANIC CHEMISTRY - COMPOUNDS

Utilize the Inorganic Nomenclature Programmed Aid and read the I.U.P.A.C. rules beginning on page 5526 "Formulas and Names of Compounds in General". Use this programmed review only after Inorganic Nomenclature is MASTERED.

---

1. If a molecular weight varies with temperature and pressure conditions; e.g. HF, H_2F_2, H_3F_3 then the ____________ possible formula is chosen. The simplest formula for S_8, S_6 and S_4 is __________. For the series NO, N_2O_2, N_4O_4 the simplest is ____________.

---

2. Why is S_4N_4 an exception to the rules?

1. simplest
S
NO

---

3. In ____________ languages (like English) the electro positive constituent is placed __________ while in Romance languages like ________________ the electronegative constituent is placed first.

2. It should be N_4S_4 but is known to be a nitride not a sulfide.

---

4. The terms hemi and sesqui are used in indicating stoichiometric proportions of _________ and ____________ respectively.

3. Germanic
first
French (Spanish, Rumanian, Italian)

EX.: potassium chloride vs. chlorurede potassium

---

5. If there are two hexafluoro arsenate groups attached to a magnesium the compound would be called ________________. If there were 3, 4, 5 or more such liquids what prefixes are used?

4. 1/2

3/2

---

5. magnesium bis (hexachloroarsenate)
tris, tetrakis. pentakis, etc..........

TM-2 ATOMIC STRUCTURE, PERIODIC TABLE AND CHEMICAL NOMENCLATURE
PACKET #4-B (cont.)

6: *Name the following 'well-established' trivial exceptions.*

BH_3 __________ SbH_2 __________

B_2H_6 __________ Si_2H_6 __________

SiH_4 __________ P_2H_4 __________

PH_3 __________ As_2H_4 __________

AsH_3 __________

7: *Some 'harmless' trivial commercial names persist. What are: soda __________, chile saltpeter ________, quicklime _________, muriate of potash ____________, muriatic acid ___________?*
NOTE: CONSULT PAGES 1577-1584 of HANDBOOK OF CHEMISTRY AND PHYSICS 44th Edition to check upon: blende, heavy spar, corundum, Kieselguhr, spirit of hartsorn, rouge, sylvine. Do you see why I.U.P.A.C. is preferred?

6. *Borane*
diborane
silane
phosphine
arsine
stibine
disilane
diphosphine
diarsine

---

8. *The ending -yl is reserved for radicals containing oxygen or other __________________. Name the radicals HO, NO_2, SO_2, UO_2, ClO ____________________________________.*

7. *sodium carbonate*
sodium nitrate
calcium oxide
potassium chloride
hydrochloric acid

---

9. *Name NO_2, SO_2 and ClO as compounds ____________________________________.*

8. *chalcogens*
hydroxyl
nitryl (nitroyl)
sulfonyl (sulfuryl)
uranyl
chlorosyl

---

9. *nitrogen dioxide*
sulfur dioxide
chlorine monoxide

---

10. In acid nomenclature hypo-denotes ______________ oxidation state. Name HOCl, HPH_2O_2, and $H_4P_2O_6$

_____________, _____________, _____________.
The prefix _____________ is used to denote higher oxidation state. Name $HClO_4$ and $HBrO_4$.

---

11. Reproduce Table II of oxo-acids in your notes for future reference.

10. lower
hypochlorous acid
hypophosphorous acid
hyphosphoric acid
per ____________
perchloric acid
perbromic acid

---

12. There are five fundamental derivatives of acids. They are __________, _________, __________, _________, and ________. Nitriles of the organic chemists are the __________ of the inorganic chemist. Anhydrides should not be called such but rather ___________________.

11. Hand into instructor for credit

---

13. Page 5543 has been reproduced for you to include in your F.I.D. notebook. How is SeCN named as an anion? A ligand?

12. acid halides
acid anhydrides
amides
esters
nitriles
nitrides
oxides

---

14. Minerals occuring in nature with similar _______ have different names according to their ________ _____ structures. Zinc blenide, ZnS has a _________ structure, which mineralogists called zinc _______ or __________ structure. Another form of zinc sulfide is hexagonal, this has the ____________structure.

13. selenocyanate

selenocyanato

---

14. compositions
crystal
cubic
blende
sphalerite
wurtzite

---

15. What has 'the commission' suggested be used for such polymorphs? (Nine abbreviations).

16. NAME THE FOLLOWING......DO NOT FOOL YOURSELF. The answers are not here. Ask instructor for answers and use this to see if you are ready for the End-of-Module Test.

15. cub=cubic
c=body-centered
f = face-centered
tetr = tetragonal
o-rh = orthorhombic
hex = hexagonal
trig = trigonal
mon = monoclinic
tric = triclinic

CO-ORDINATION COMPOUNDS

a. $K_2[NiF_6]$ b. $Rb_2[Cr(O)_2O_2(CN)_2(NH_3)]$

c. $Na_3Ag(S_2O_3)_2$

17. MIXED - SALTS

$NaNbO_3$ $KMgF_3$ $LiNH_4HPO_4 \cdot 4H_2O$

18. CHLORO-ACIDS

$HAuCl_4$ H_2SnCl_6 $H[B(C_6H_5)_4]$

19. OXO & PEROXO-ACIDS

HNO_4 H_2SO_5 $HMnO_4$

20. Well established trivial names.

B_2H_6 PH_3 AsH_3

PACKET #5 - REPRODUCING YOUR OWN PERIODIC TABLE

In this exercise you are to produce your own, wall-sized PERIODIC CHART. It is hoped that the physical production of the chart which Dobereinar (1800), Newlands (1864), Mayer (1869) and Mendeleev (1869) worked upon for so long will aid in collecting chemical thoughts.

You are to produce seven horizontal PERIODS. Each period, with the exception of the first, starts with an alkali metal and ends with a noble gas. The vertical columns of elements which are formed have identical (or similar) outer-shell electron structures. These are chemical groups of families of elements

Make your chart just smaller than the drafting tables in Room 207. Use best drafting techniques. The basic shape will be given to you. Use light pencil to outline and then print all information required.

PERIODS OF ELEMENTS

The first period contains two elements, hydrogen and helium, and coincides with the full K shell of electrons. Period 2 contains eight elements, starting with lithium and ending with neon. Period 3 also contains eight elements, sodium to argon. Periods 4 and 5 each contain 18 elements; Period 6 has 32 elements; and Period 7, which is incomplete, contains the remaining 17 elements.

The first three periods are known as short periods, the others as long periods. The number of each period corresponds to the outermost electron shell in which electrons are located in the neutral atom. For example, the elements in period 1 contain electrons in the K shell only; period 2 elements contain electrons in the K and L shells; period 3 elements contain electrons in the K, L and M shells etc. Moving horizontally across periods 2 through 6, we find that the properties of elem ents vary from strongly metallic at the beginning of the period to non-metallic at the end of the period. Starting with the third element of the long periods 4, 5, 6, and 7 (scandium, Sc; yttrium, Y; Lanthanum, La; actinium, Ac), the inner shells of electrons begin to fill in toward their maximum number of electrons.

GROUPS OF ELEMENTS

The groups are numbered IA-VIIA, IB-VIIB, VIII and noble gases. The first major distinction to notice between groups is that the last electron added in the elements of Groups IA-VIIIA, IB, IIB and the noble gases is either an s or p orbital electron and is located in the outermost electron shell (copper, Cu, is an exception). The last electron added in an element of Groups IIIB-VIIB and VIII is a d or f orbital electron, it is located in an inner electron shell.

THE GENERAL CHARACTERISTICS OF GROUP PROPERTIES ARE:

1. The number of electrons in the outer shell of Groups IA-VIIA, IB and IIB elements is the same as the group number. The other B groups and Group VIII do not show this property. The noble gases, except helium, have eight electrons in their outer shell.

---

2. The group number in which an element is located will indicate one of its possible oxidation states, with some exceptions, especially in Group VIII

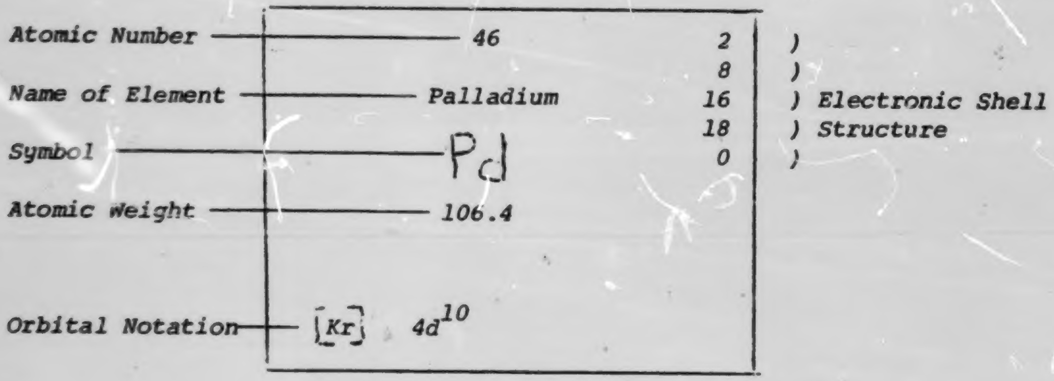
3. The groups on the left and middle sections of the table tend to be metallic in nature. The groups on the right tend to be non-metals.

4. The radii of the elements increase as one goes from top to bottom within a particular group (i.e., lithium to francium).

5, Elements at the bottom of a group tend to be more metallic in their properties than those at the top. This tendency is especially noticeable in Groups IVA-VIIA.

6. Elements within a group have similar electron structures and will show some similarities in their chemical properties.

EACH ELEMENT IS TO HAVE THE INFORMATION AS SHOWN BELOW.


Atomic Number
46
Name of Element
Palladium
Symbol
Pd
Atomic Weight
106.4
Orbital Notation
[Kr] 4d10
2
8
16
18
0
Electronic Shell Structure

TM - 2 END OF MODULE EXAM

WITHOUT ANY NOTES WHATSOEVER REPRODUCE THE PERIODIC TABLE USING THE FOLLOWING PROCEDURE:

1. Alkali metals in red.
2. Alkaline earth metals in blue
3. Show where 14 Lanthanide metals and 14 Actinide metals 'fit' into place. (It is not required to know these by position.)
4. Iron-triad-green
5. Aluminum family-orange
6. Carbon family grey
7. Chalcogens-yellow
8. Nitrogen family-green
9. Halogens-brown
10. Inert gases-colorless
11. Nobel metals-violet
12. Show dark line separating metals from non-metals.
13. Show red line separating heavy metals from light metals.

TM-3 SOLUTION CHEMISTRY

PURPOSE:

To assist the student learn the theories and practices used by chemists who work with aqueous solutions and suspensions.

MATERIALS:

1. Runquist, O.A., C.G. Creswell, and J. T. Head. Chemical Principles: A Programmed Text: Part I
Burgess Publishing Co., 426 South Sixth Street,
Minneapolis, Minn., 55415

2. Communication Skills Corporation Slide-Tape Presentations.

#814 Preparing Solutions

#831 Atomic Weights and the Mole Concept

#896 Preparing Molar and Normal Solutions

Communication Skills Corporation, P. O. Box 684,
Fairfield, Connecticut, 06430

3. Leicester, H. M. The Historical Background of Chemistry. John Wiley & Sons, Inc., N. Y.

4. Sienko, M. J. and R. A. Plane, Chemistry, 5th Edition, McGraw-Hill.

5. O'Connor, R. Fundamentals of Chemistry, 2nd Edition, Harper & Row.

OBJECTIVES: To enable the student to:

1. Prepare molar, formal. molal and normal solutions.

2. Determine properties of colloidal suspensions.

TM-3 SOLUTION CHEMISTRY

INSTRUCTION AND CHECKOFF SHEET DATE STARTED: ____________________

PACKET #1

ATOMIC WEIGHTS AND THE MOLE CONCEPT - CSC - #831

Review before going on in this unit. If not already completed in TM-1 - Complete self quizzes and hand in End of Unit Test to instructor for correction.

Date Completed ______________________________

Instructor Sig.: ___________________________

PACKET #2

FORMULA, ATOMIC WEIGHT, MOLECULAR WEIGHT AND MOLES.

Use Runquist I directly - pgs. 40-53.

Date Completed: ___________________________

Instructor Sig.: ___________________________

PACKET #3

PREPARING SOLUTIONS - CSC slide-tape unit #814

Complete self quizzes and hand in End of Unit Test to Instructor for correction.

Date Completed: ___________________________

Instructor Sig.: ___________________________

PACKET #4

CONCENTRATION OF SOLUTIONS

Runquist I directly - pgs. 63-67

Date Completed: ___________________________

Instructor Sig.: ___________________________

PACKET #5

PREPARING, MOLAR AND NORMAL SOLUTIONS - CSC slide-tape unit #896

Complete self quizzes and hand in End of Unit Test to instructor for correction.

Date Completed: ___________________________

Instructor Sig.: ___________________________

TM-3 SOLUTION CHEMISTRY

INSTRUCTION AND CHECKOFF SHEET (cont.)

PACKET #6

Read: SIENKO AND PLANE - Section on Colloids

LEICESTER: The Historical Background of Chemistry - Chapter 21
19th century.

BE SURE TO KEEP 3" x 5" CARDS ON SCIENTISTS ENCOUNTERED IN THE READING.

PUT NEW PROCEDURES ENCOUNTERED IN READING ON KRITTER SHEETS FOR TECHNIQUE SECTION OF F.I.D. NOTEBOOK.

REQUEST PROGRAMMED REVIEW.

Date Completed: ______________________

Instructor Sig.: ______________________

PACKET #7

Liquids - Runquist I directly - pgs. 211-216

Date Completed: ______________________

REQUEST END OF MODULE TEST __________ Date Completed: ______________________

Instructor Sig,: ______________________

TM-3 SOLUTION CHEMISTRY

PACKET #1 - #831 ATOMIC WEIGHTS AND THE MOLE CONCEPT - SELF QUIZZES

SECTION I - USING THE PERIODIC TABLE WRITE THE ATOMIC WEIGHTS FOR THE FOLLOWING ELEMENTS TO THE NEAREST 0.1 a.m.u.

1. Magnesium (Mg) ____________________
2. Manganese (Mn) ____________________
3. Silicon (Si) ____________________
4. Lithium (li) ____________________
5. Zinc (Zn) ____________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 9

SECTION 2 - CALCULATE THE MOLECULAR WEIGHTS OF THE FOLLOWING MOLECULES. USE A PERIODIC TABLE TO OBTAIN THE ATOMIC WEIGHTS OF THE ELEMENTS.

1. Calcium Carbonate ($CaCO_3$) ____________________
2. Nitric Acid (HNO_3) ____________________
3. Sodium Chloride (NaCl) ____________________
4. Acetic Acid (CH_3CO_2H) ____________________
5. Sucrose ($C_{12}H_{22}O_{11}$) ____________________
6. Nitrogen (N_2) ____________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION 3 - PART I - CALCULATE THE WEIGHT OF 1 MOLE OF THE FOLLOWING ELEMENTS OR COMPOUNDS. USE A PERIODIC TABLE TO OBTAIN ATOMIC WEIGHTS.

1. Water (H_2O) ____________________
2. Sodium (Na) ____________________
3. Sucrose (C_{12} $H_{22}O_{11}$) ____________________
4. Calcium Carbonate ($CaCO_3$) ____________________
5. Sodium Chloride (NaCl) ____________________
6. Hydrochloric Acid (HCl) ____________________

TM-3 SOLUTION CHEMISTRY
PACKET #1 - #831 - SELF QUIZZES (cont.)

SECTION 3 - PART 2

1. How many atoms in 23.0 grams of Sodium? ________________________

2. How many molecules in 78.0 grams of Benzene? ________________________

3. How many molecules in 18.0 grams of Water? ________________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 20.

SECTION 4 - CALCULATE THE WEIGHT IN GRAMS, GIVEN THE NUMBER OF MOLES OF THE FOLLOWING COMPOUNDS.

1. 2.0 moles of Water (H_2O) ________________________

2. 2.0 moles of Nitric Acid (HNO_3) ________________________

3. 2.0 moles of Magnesium (Mg) ________________________

4. 1,5 moles of Methane (CH_4) ________________________

5. 1,5 moles of Carbon Dioxide (CO_2) ________________________

6. 5 moles of Benzene (C_6H_6) (mol. wt. = 78.0) ________________________

7. 0.2 moles of Glucose ($C_6H_{12}O_6$) (mol. wt. = 180.0) ________________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 22.

SECTION 5 - CALCULATE FROM THE GRAMS GIVEN THE NUMBER OF MOLES IN THE FOLLOWING COMPOUNDS.

1. 3600 grams of H_2O (mol. wt. = 18.0) ________________________

2. 960 grams of Methane (mol. wt. = 16.0) ________________________

3. 315 grams of Nitric Acid (mol. wt. = 63.0) ________________________

4. 6 grams of Acetic Acid (mol. wt. = 60.0) ________________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 24.

TM-3 - SOLUTION CHEMISTRY

PACKET #3 - CSC #814 - PREPARING SOLUTIONS - REVIEW EXERCISE

REVIEW EXERCISE - WHEN YOU HAVE COMPLETED THIS EXERCISE, GIVE THE ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION AND PLACEMENT INTO YOUR FOLDER AND CREDIT ON YOUR INSTRUCTION SHEET AND CHECKOFF SHEET.

---

1. A solution must have a fixed amount of solute and solvent which cannot be varied.

   TRUE ________________ OR FALSE ________________

2. When no further solute will dissolve in a solution, it is said to be __________.

3. Three terms for expressing the concentration of a solution are ______________, ____________ and ______________.

4. A 1 M solution contains one _________ of __________ per liter of solution.

5. What is the normality of (a) 1 Molar solution of HCl and (b) 1 Molar solution of H_2SO_4?

   A. ____________________________________

   B. ____________________________________

6. For most solutes, increasing the temperature __________ the rate at which solute dissolves in solution.

7. If you were asked to prepare 500 ml of a 1 Molar solution of potassium dichromate ($K_2Cr_2O_7$, mol. wt. 294.21) how many grams of solute would you add to 500 ml of solution.?

8. If you dissolved 200 mg of NaOH in distilled water to make 1 liter of solution what would be the Molarity of the solution?

9. In preparing acid solutions by dilution, what general rule must you always follow?

10. How many milliliters of concentrated hydrochloric acid would be needed to prepare 1 liter of 5N HCl? (Reagent grade concentrated hydrochloric acid has density of 1.18 g/ml and contains 38.0 g of HCl per 100 g of solution; g mol. wt. of HCl = 36.457g/mol).

NAME: ______________________________

DATE: ______________________________

TM - 3 SOLUTION CHEMISTRY

PACKET #3 - ATOMIC WEIGHTS AND THE MOLE CONCEPT - FINAL REVIEW EXERCISE #831

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1. *Using your periodic table, find the atomic weights of the following elements.*

   A. CARBON ____________________

   B. NITROGEN ____________________

   C. HYDROGEN ____________________

   D. OXYGEN ____________________

   E. POTASSIUM ____________________

   F. IODINE ____________________

2. *Calculate the molecular weight of these molecules.*

   A. NH_3 - Ammonia ____________________

   B. KI - Potassium Iodide ____________________

   C. O_2 - Oxygen ____________________

   D. CO - Carbon Monoxide ____________________

   E. C_2H_2 - Ethane ____________________

3. *Calculate the weight in grams of the following:*

   A. 1 mole of Ammonia molecules (NH_3) ____________

   B. 2 moles of Oxygen molecules (O_2) ____________

   C. 0.1 moles of CO molecules ____________

4. *How many moles of atoms or molecules are there in the weight of these substances?*

   A. 117.3 grams of Potassium (K) ____________________

   B. 2.8 grams of Ethane (C_6H_6) ____________________

   C. 85 grams of Ammonia (NH_3) ____________________

   D. 320 grams of Oxygen molecules (O_2) ____________________

WHEN FINISHED HAND INTO INSTRUCTOR FOR HIS EVALUATION.

NAME: ____________________________

DATE: ____________________________

TM-3 SOLUTION CHEMISTRY

PACKET #5 - 896 - SELF QUIZZES

---

1. The dissolved substance in a solution is called the ________________ and the dissolving substance the ________________.

2. A solution is saturated when the amount of ________________ dissolved is in equilibrium with ______________ solute.

3. In a solution the amount of dissolved substance, the solute, cannot be varied in a given amount of solvent.

   TRUE ______ FALSE ______

   ______ ______

4. What are the three ways of expressing solution concentration as a percentage?

   1. ____________________ 2. ________________ 3. ________________

5. How many grams of NaCl are required to prepare 100 ml of a 5% by wt-vol solution?

6. What is the percent by wt-vol of 0.50 grams of NaCl in 50 ml of solution?

7. To prepare a 100 ppm solution of iron you dissolve _____________ grams of iron in 100 ml of solution.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION 2

1. The MOLARITY of a solution is the number of ______________ of solute per ______________ of solution.

2. A 5% solution of potassium hydroxide contains the same number of moles of solute as a 5% solution of H_2SO_4.

   TRUE ________ FALSE ________

   ________ ________

3. What is the molarity of a solution which contains 0.50 moles of solute in 50 ml of solution?

4. How many grams of potassium permanganate ($KMnO_4$), mol. wt.: 158) are required to prepare 350 ml of a 0.500 M solution?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 20.

SECTION 3

1. What is the molarity of a concentrated solution of hydrochloric acid, which has a density of 1.20 g/ml, and a concentration of 37.0 wt %? (mol. wt. of HCl = 36.5

2. How many milliliters of concentrated nitric acid (KNO_3) are needed to prepare 2.0 liters of a 0.10 M solution? (Density of concentrated HNO_3 = 1.41 g/ml; wt. % 70, mol. wt. of HNO_3 = 63.0).

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 22.

SECTION 4

1. The NORMALITY of a solution is the number of ____________ of solute per __________ of solution.

2. A 1.0 M solution of HCl is _____________ N.

3. A 2.0 N solution of H_2SO_4 is ______________ M.

4. A 3.0 solution of H_2SO_4 is _______________ N.

5. How many grams of carbonic acid (H_2CO_3 , mol. wt. 62) must be dissolved in 800 ml of water, to obtain a 0.30 N solution?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 26.

PACKET #5 - 896 - REVIEW QUIZ

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1. *Percent by weight means ____________ of solute divided by grams of ________________ times _______________?*

2. *What is the percent by weight-volume of 23.5 grams of sodium chloride dissolved in 100 ml of solution?*

3. *A 10 ppm solution of iron contains _____________ grams of iron in 1000 ml of solution.*

4. *What is the molarity of a 5.0% wt-vol solution of potassium permanganate (mol wt of* $KMnO_4$ *= 158)?*

5. *How mant grams of sodium hydroxide (mol wt - 40) are needed to prepare 250 ml of a 0.10 M solution?*

6. *How many moles of HCl are there in 100 ml of a concentrated solution of density 1.2 g/ml containing 37% of HCl by weight? (mol wt of HCl = 36.5).*

7. *A 6.0 N* H_2SO_4 *solution is ________________molar.*

8. *How many milliliters of concentrated* H_2SO_4 *are needed to prepare 500 ml of a 3.00 N solution? (density of conc.* H_2SO_4 *= 1.83 gm/ml, wt % = 95.5, mol wt = 98.1)*

GIVE THE COMPLETED ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________________

DATE: ______________________________

TM-3 - SOLUTION CHEMISTRY

PACKET #6 - Read Sienko and Plane - Section on Colloids
Read Leicester - The Historical Background of Chemistry - Chap. 21 - 19th century.

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1. Physical chemistry made its greatest advances in the 19th century while ________ and photochemistry only started then. The laws relating volume and temperature in gaseous changes was discovered by ___________ in 1787, and the gas constant, R, was found by ____________ early in the century. Dynamic equilibrium was introduced by Pierre __________ early in the century.

---

2. Wenzel in 1777 studied chemical ___________ by observing rates at which _________ dissolved in acids. He failed in his attempts but opened up the field of ___________________.

1. colloid
   Charles
   Regnault
   Prevost

---

3. Leaders in developing the modern concept of dynamic ___________ are Ludwig ___________, and Williamson, but it was the Norwegians _________ and ____________ who in 1863 put forward the concept of ____________ _________.

2. affinity
   metals
   kinetics

---

4. The _____________ of reacting substances constituted the '________' that determined the equilibrium resulting from the forward and reverse reactions Thus Goldberg, Waage and van't Hoff's work in 1879 completed the work begun by ________ in 1801.

3. equilibrium
   Wilhelmy
   Goldberg & Waage
   mass action

---

5. The concept of 'activation energy' was proposed by Svante ________ who combined solution chemistry with kinetics, The iatrochemical notion of '__________' promoting reaction reached reality when the lead chamber process was invented by _____________ and Clement.

4. concentration
   active mass
   Berthollet

---

6. Catalysis as a process became understandable after _________ ________ __ oxidized organic chemicals using metal surfaces as 'sites', and the hydrolysis of starch in the presence of _________ by ____________. The theory of catalysis, and the word itself emanated from the fertile mind of the Swedish chemist ______________.

5. Arrhenius
   ferments
   Desormes

---

6. Humphry & Ed. Davy
   acid
   Kirchhoff
   Berzelius

7. The foundations of colloidal chemistry were laid by Thomas ____________ who discovered differential ________________. At first animal _____________ were used in dialysis studies but in 1867 Moritz ____________ prepared the first artificial membranes. The botanist, ____________ used these membranes to study ____________ pressure. That the gas law and ____________ laws were the same in ______________ solution was shown by ______________________.

8. The freezing point method for determining ______________ weights was discovered by _____________. Dissociation of dissolved solutes was first suggested by _____________ in 1857, although as early as 1805 ____________________ had suggested what is now called ________________.

7. Graham
diffusion
membranes
Traube
Pfeffer
osmotic
osmotic
dilute
van't Hoff

9. The first modern bimettallic battery was invented by _______________ and the lead storage battery was invented by ______________________ in 1859.

8. molecular
Raoult
Deville
Grotthuss
electrolysis

9. Daniell
Plante

---

10. "All the necessary data for the final synthesis were now at hand. The ____________ theory was announced to the Swedish Academy of Sciences by _______________ in 1883". Electrolytic conduction had been explained by ______________ and _____________; osmotic anomalies were considered by ____________ and ______________. Arrhenius led the way for ____________ to explain differences in acid-base ____________ and for ______________ to develop his ideas on solution _________________, electromotive ____________ and the _______-_______ effect.

---

11. For the size range of particles between 10^{-7} and 10^{-4} cm the dispersion is called a ____________, a _______________suspension, or a _______________ solution.

10. dissociation
    Svante Arrhenius
    Hittorf
    Kohlrausch
    Raoult
    van't Hoff
    Oswald
    strengths
    Nernst
    pressure
    force
    common-ion

---

12. The colloidal particle may consist of ___________, of small ________________, or of one giant _____________. Red glass is a colloid of ________ atoms, the 'wettable' sulfur used as a spray against fungus infection of Rosaceae is a colloid of S_8 _________, the red color of blood is colloidal ________________.

11. colloid
    colloidal
    colloidal

---

12. atoms
    molecules
    molecule
    gold
    molecules
    hemoglobin

---

13. If a solid is dispersed through a liquid it is a ____________, If a liquid is dispersed in a liquid it is termed an ______________. If a network of solid extends through a liquid it is a ____________. An ____________ is a colloid of solid or liquid in a ____________. Do you know what the Tyndall effect is? Who is he?

14. The wig-wag motion of colloidal particles which is reflected in a Tyndall beam is ______________ motion. Who discovered this phenomenon? ______________. Ferric oxide forms a ___________ charged sol. Arsenious sulfide (arsenic sulfide) forms a ___________charged sol. If two such oppositely charged sols are mixed they _________ ___________. This is observed when charged clay particles meet sea water and deposit ___________.

13. sol
emulsion
gel
aerosol
gas

15. One of the most characteristic properties of matter in a finely divided condition is its extremely large ____________. Atoms at the __________ of particles usually do not have their ____________ satisfied. Clay minerals and ____________ are common colloidal substances used for ____________ processes.

Do not confuse adsorption which is a __________ phenomenon with absorption which involves the whole solid drawing the absorbed material into itself.

14. Brownian
Brown
positively
negatively
coagulate
slimes

15. surface area
surface
valences
charcoal
adsorption
surface

TM-3 END OF MODULE TEST

1. Why are atomic weights not whole numbers?

2. How do you determine molecular weight, given the formula of a crystalline substance?

3. What is the difference between molar formal, molal, and normal solutions?

4. Give step-by-step procedures for the preparation of the above solutions.

5. Give examples of several different types of colloids: e.g. gas in solid, solid in gas, liquid in gas, etc.

PERIODIC CHART OF THE ELEMENTS

THE SYMBOL. Shown in the middle of each block directly below the name of the element. The color used indicates the physical state of the element under ordinary conditions: black for solids, green for liquids and blue for gases.

THE ATOMIC WEIGHT. Directly below the symbol for each element the atomic weight is shown in black. The values are taken from the official Report on Atomic Weights Cf. J. Amer. Chem. Soc. 84, 4193 (1962). For elements not listed in the Report the mass number of the longest lived isotope is shown in brackets.

THE ATOMIC NUMBER. Shown in red in the upper left hand corner.

ELECTRONIC CONFIGURATION. Shown at the upper right as a group of black numerals. When read downward they indicate the number of electrons normally found in successive energy levels.

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1	1 H 1.00797																	2 He 4.0026
2	3 Li 6.939	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
3	11 Na 22.9898	12 Mg 24.312											13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 A 39.948
4	19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99.)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
6	55 Cs 132.905	56 Ba 137.34	57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.05	89 Ac 227.04															

* Lanthanide Series →	58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
** Actinide Series →	90 Th 232.038	91 Pa 231.05	92 U 238.03	93 Np 237.06	94 Pu (242)	95 Am (243)	96 Cm (245)	97 Bk (249)	98 Cf (249)	99 Es (253)	100 Fm (255)	101 Md (256)	102 No (253)	103 Lw (257)

[illegible] EDUCATIONAL
MATERIALS DIVISION
[illegible]
Chicago, Illinois [illegible]

TM-4 CHEMICAL REACTIONS

PURPOSE:

To aid the student in understanding chemical equations, reaction mechanisms, kinetics and equilibria.

MATERIALS:

1. Walker, R. A. and H. Johnston. The Language of Chemistry. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
2. Kass, G. A. Individual Study Program in Chemistry - Vol. III & IV. W. A. Benjamin, Inc., N. Y., N. Y., 10016.
3. Runquist, O. A., C. J. Creswell & J. T. Head. Chemical Principles: Part II. Burgess Publishing Co., 426 South Sixth Street, Minneapolis, Minn., 55415
4. Communication Skills Corporation Slide-Tape Presentations.

   #881 - Chemical Equilibrium

   Communication Skills Corporation, P. O. Box 684, Fairfield, Conn., 06430.

OBJECTIVES: To enable the student to:

1. Write and balance chemical equations.
2. Calculate chemical equilibrium constants.
3. Determine concentrations of chemical species in solutions.
4. Predict reaction direction.
5. Utilize Kinetic and equilibrium theory to follow elemental reactions.

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA

INSTRUCTION AND CHECKOFF LIST

INTRODUCTION: In this module you will learn how to write chemical equations, and utilize kinetic and equilibrium concepts to follow chemical reactions. The five packets may be studied in any convenient order although Packet #1 is a partial review to lead into this area of chemistry.

PACKET #1 - Read Walker & Johnston: THE LANGUAGE OF CHEMISTRY, pgs. 1-49. Complete the exercises on pages 10 & 11; 22 & 23; 31 & 32 & 49. Submit exercises to instructor and correct.

Date Completed: __________

Instructor Sig.: __________

PACKET #2 - Utilize slide-tape presentation #881 - Chemical Equilibrium. Take self quizzes and end of unit test and submit to instructor for correction.

Date Completed: __________

Instructor Sig.: __________

PACKET #3 - Read The Forces that Drive Chemical Reactions. Take end of packet Diagnostic Test, submit to instructor and correct.

Date Completed: __________

Instructor Sig.: __________

PACKET #4 - Read Kinetics and Equilibrium. Take end of packet Diagnostic Test, submit to instructor and correct.

Date Completed: __________

Instructor Sig.: __________

PACKET #5 - Utilize Part II of Runquist, Creswell and Head: *Chemical Principles* - Chapter 7 - THERMODYNAMICS & KINETICS *and* Chapter 8 - CHEMICAL EQUILIBRIUM.

Date Completed: __________

Instructor Sig.: __________

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA
INSTRUCTION AND CHECKOFF LIST (cont.)

NOW ASK FOR END OF MODULE TEST.

WRITTEN EXAM GRADE ______________________

DATE MODULE COMPLETED: ____________________

INSTRUCTOR SIG.: __________________________

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA
PACKET #2 - #881 - "CHEMICAL EQUILIBRIA: MOLECULAR AND IONIC PROBLEMS INVOLVING K_{eq} & K".

SECTION ONE:

1. List four factors which affect the rate of a chemical reaction.

   a. b.

   c. d.

2. The Law of Mass Action states that the ____________________ of a chemical reaction is _________________ to the _____________ of the _____________ of the reacting substances, each raised to the power corresponding to the _____________ of that species in the balanced chemical equation.

3. When two opposing reactions are occuring at the same rate, the reaction system is in ___________________________.

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION TWO:

1. Write expressions for the equilibrium constants of each of the following reactions.

   A. $2SO_2 + O_2 \rightleftharpoons 2SO_3$

   B. $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

   C. $N_2O_4 \rightleftharpoons 2NO_2$

2. Analysis of an equilibrium mixture of: $CO_2 + H_2 \rightleftharpoons CO + H_2O$ at $700^{\circ}K$ gave the following concentrations:

   $[CO]$ + = 7.0 mol/l., $[H_2O]$ = 0.21 mol/l., $[CO_2]$ = 5.0 mol.l., and $[H_2]$ = 3.0 mol/l. CALCULATE K_{eq} for this equilibrium.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 23.

SECTION THREE:

A weak acid HA ionizes as follows: $HA + H_2O \qquad H_3O^+ + A^-$.

A 0.2 M solution of HA is 1% ionized at 25C. Calculate K_a for this acid at 25C.

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 29.

SECTION FOUR:

A weak acid HA ionizes as follows: $HA + H_2O \qquad H_3O^+ + A^-$.

The acid concentration is 1.0×10^{-2} M and $K_a = 10^{-3}$. Calculate the hydronium ion concentration H_3O^+. The answer to this problem requires the solution of a quadratic equation. The formula solution of the general quadratic

$$ax^2 + bx + c = 0 \text{ are:}$$

$$\frac{-b \ ^{+} \ b^2 - 4ac}{2a}$$

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 33.

SECTION FIVE:

USE THE APPROXIMATE FORMULA JUST DISCUSSED TO THE CALCULATIONS IN THIS SECTION.

1. Calculate the H_3O^+ concentration in the solutions of the following weak acids.

   A 1.0 M formic acid, $K_a = 1.8 \times 10^{-4}$

   B. 1.0 M acetic acid, $K_a = 1.8 \times 10^5$

---

2. Calculate the OH^- concentration in the solutions of the following weak bases.

   A. 0.1 M NH_3, $K = 1.8 \times 10^{-5}$

   B. 0.01 M pyridina, $K_b = 6.5 \times 10^{-6}$

WHEN YOU HAVE COMPLETED YOUR ANSWERS RESTART THE TAPE AND ADVANCE TO FRAME 39.

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA
PACKET #2 - #881 - END OF PACKET QUIZ

---

1. Write the equilibrium constant for each of the following reactions:

   A. $2NOCl \quad - \quad 2NO + Cl_2$

   B. $COCl \quad - \quad CO + Cl_2$

   C. $H_2 + I_2 \quad 2HI$

2. A 0.5 M solution of a monoproctic weak acid is 2% ionized. Calculate K_a for the acid.

3. Calculate the hydronium ion concentration H_3O^+ in a 0.05 M solution of hydrofluoric acid HF. K_a for HF is 4×10^{-4}. (Hint: You must solve the quadratic in this problem).

4. Calculate the ammonium ion (NH_4^+) concentration in 0.1 M NH_3 solution, K_b for $NH_3 = 1.8 \times 10^{-5}$. (Use the approximate formula)

5. Calculate the hydronium ion concentration H_3O^+ in a 0.5 M solution of a monoprotic weak acid HA.

   $K_a = 5.0 \times 10^{-5}$

NAME: ______________________

DATE: ______________________

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA
PACKET #3 - THE FORCES THAT DRIVE CHEMICAL REACTIONS

DIAGNOSTIC TEST: MULTIPLE CHOICE

1. ________ In the reaction $H + H = H_2$, potential energy:

A. increases; B. decreases; C. stays the same.

2. ________ The word 'enthalpy" is best related to: A. randomness; B. heat content; C. physical; D. pressure.

3. ________ When the energy content of the product in a reaction is greater than the energy content of the reactants: A. energy is absorbed; B. energy is released; C. energy is both absorbed and released; D. energy is neither absorbed nor released.

4. ________ Given the reaction: $1/2N_{2(g)} + 1/2O_{2(g)} + 21.6$ kcal

$= NO_{(g)}$. The ΔH for the reaction between 1 mole of nitrogen and

1 mole of oxygen is: A. -21.6 kcal; B. +21.6 kcal; C. -43.2

kcal; D. +43.2 kcal.

USE APPROPRIATE TABLES TO ANSWER QUESTIONS 5, 6, and 7 as well as any others that may require tabulated information.

5. ________ The H for the decomposition of 36 g of liquid water is: A. -68.3 kcal; B. +68.3 kcal; C. -136.6 kcal; D. +136.6 kcal.

6. ________ The heat formation of gaseous water is: A. 68.3 kcal; B. +68.3 kcal; C. -57.8 kcal; D. +57.8 kcal.

7. ________ The H for the evaporation of 1 mole of liquid water in kilocalories is: A. +10.5; B. -10.5; C. +57.8; C. -68.3.

8. ________ Given the reaction: $N_{2(g)} + 3H_2 = 2NH_{3(g)} + 22$ kcal,

The H is: A. -11 kcal; B. +11 kcal; C. -22 kcal; D. +22 kcal.

9. ________ When chemical bonds form: A. energy is released only B. energy is absorbed only; C. energy is both released and absorbed; D. energy is neither released nor absorbed.

10. ________ The energy of an O-H bond is given as 109 kcal per mole. This means that when the bonds needed to produce a mole of water are formed: A. 109 kcal are released; B. 109 kcal are absorbed; C. 218 kcal are released; D. 218 kcal are absorbed.

---

11. ________ The absolute entropy of ammonia gas is 46.0 e.u. A S^0 value for liquid ammonia might be: A. 27; B. 46; C. 63; D. 92.

12. ________ Which equation represents the H_f (enthalpy of formation) of solid calcium hydroxide? A. $Ca_{(s)} + O_{2(g)} + H_{2(g)} = Ca(OH)_{2(s)}$

B. $Ca^{+2}_{(aq)} + 2OH^-_{(aq)} + Ca(OH)_{2(s)}$

C. $Ca_{(s)} + 2O_{(g)} + 2H_{(g)} + Ca(OH)_{2(s)}$

D. $CaO_{(s)} + H_2O_{(l)} = Ca(OH)_{2(s)}$

13. ________ Given the two reactions: $S_{(s)} + O_2 = SO_{2(g)}$

$\Delta H = -70.96$ kcal

$S_{(s)} + \frac{3}{2}O_{2(g)} = SO_{3(g)}$ $\Delta H = -94.50$ kcal

The H for $SO_{2(g)} + 1/2O_{2(g)} = SO_{3(g)}$ in kilocalories is:

A. +70.96; B. -23.54; C. +23.54; D. +165.41

14. ________ When 1 mole of methane gas (CH_4) is burned in sufficient oxygen, the heat of the reaction is -210 kcal. This means that: A. 210 kcal are released; B/ 210 kcal are absorbed; C. 210 kcal are released; B. 210 kcal are absorbed; C. 210 kcal are first absorbed, then released.

15. ________ Which of the following values for heat of formation shows that the compound is the least stable? A. -94.0; B. -231.6; C. +21.4; D. +64.8.

16. ________ According to the definition for heat of formation, which is a reasonable value for the H_f of the element oxygen, $O_{2(g)}$? A. 0; B. -26; C. +26; D. -52

17, ________ If the ΔS for a certain chemical change is +28.4 e.u., the entropy driving force is: A. favorable; B. unfavorable; C. remains the same.

18, ________ As carbon dioxide gas dissolves in water, the entropy of the CO_2: A. increases; B. decreases; C. remains the same.

19, ________ As water changes from ice to liquid to steam, its entropy A. increases; B. decreases; C. remains the same

20, ________ The dissolving of NH_4Cl in water is endothermic, yet this salt does dissolve in water spontaneously. The statement that best explains this is: A. the bonds in solid NH_4Cl

are very weak; B. the entropy driving force causes solution; C. endothermic processes are energetically favorable; D. the dissolving process

21, ________ The dissolving of ammonium chloride (NH_4Cl) in water is endothermic. This means that: A. lattice energy is greater than hydration energy; B. lattice energy is less than hydration energy; C. lattice energy is equal to hydration energy; D. one cannot say anything about lattice energy compared to hydration energy.

22, ________ Given the following reaction, with the absolute entropy of each compound indicated under each formula:

$$\underset{S^0\ 26.8\text{ e.u.}}{BaCO_{3(s)}} = \underset{16.8\text{ e.u.}}{BaO_{(s)}} + \underset{51.1\text{ e.u.}}{CO_{2(g)}}$$

the ΔS for this reaction in entropy units is:

A. 41.1 B. 94.7 C. -41.1 D. -94.7

23. ________ A reaction in which the ΔH is negative and the ΔS positive is likely to be: A. spontaneous; B. not spontaneous; C. unpredictable

24, ________ A reaction in which the ΔH is negative and the ΔS negative is likely to be: A. spontaneous; B. not spontaneous; C. unpredictable

25. ________ A reaction in which the ΔH is positive and the ΔS is negative is likely to be: A. spontaneous; B. not spontaneous; C. unpredictable

26. ________ A reaction in which the ΔH is positive and the ΔS is positive is likely to be: A. spontaneous; B. not spontaneous; C. unpredictable.

---

27. _______ Chemical reactions tend to proceed spontaneously in the direction of: A. higher entropy and higher enthalpy; B. higher entropy and lower enthalpy; C. lower entropy and lower enthalpy; C. lower entropy and higher enthalpy

28. _______ The ΔH for a certain reaction is +52 kcal $mole^{-1}$, and the ΔS is 80 cal $mole^{-1}$ deg^{-1}. If the reaction is run at a temperature of 1000°K, the ΔG is: A. -28 kcal; B. +28 kcal; C. -132 kcal; D. +32 kcal

29. _______ The ΔH for a certain reaction is +20 kcal $mole^{-1}$ and the ΔS is +50 cal $mole^{-1}$ deg^{-1}. The temperature at which this reaction will proceed spontaneously is: A. 400°K; B. 400°C; C. 100°K; D. 100°C.

30. _______ The ΔG for a certain chemical change = -142.8 kcal. This reaction is: A. spontaneous; C. not spontaneous; C. unpredictable

HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________________

DATE: ______________________________

TM-4 CHEMICAL EQUATIONS, REACTIONS, KINETICS & EQUILIBRIA
PACKET #4 - KINETICS AND EQUILIBRIA - DIAGNOSTIC TEST

MULTIPLE CHOICE

1. ________ In the reaction: $H_{2(g)} + I_{2(g)} + 11.9\ kcal = 2HI_{(g)}$, the concentration of HI can be increased by: A. increasing the pressure; B. decreasing the pressure; C. increasing the temperature; D. decreasing the temperature.

2. ________ Whether a chemical reaction takes place in one step or in four is primarily a problem of: A. kinetics; B. thermodynamics; C. both kinetics and thermodynamics; D. neither kinetics nor thermodynamics.

3. ________ Reasonable units for stating quantitatively the rate of a reaction might be: A. moles per liter; B. fast or slow; C. moles per liter per minute; D. liters.

4. ________ To be effective, a collision must have: A. a sufficient ΔH; B. a favorable free energy; C. a sufficient time of contact; D. enough energy and a favorable geometry.

5. ________ In Figure 1, the activation energy requirement for the forward reaction is represented by letter: A. A; B. B; C. C; D. D.

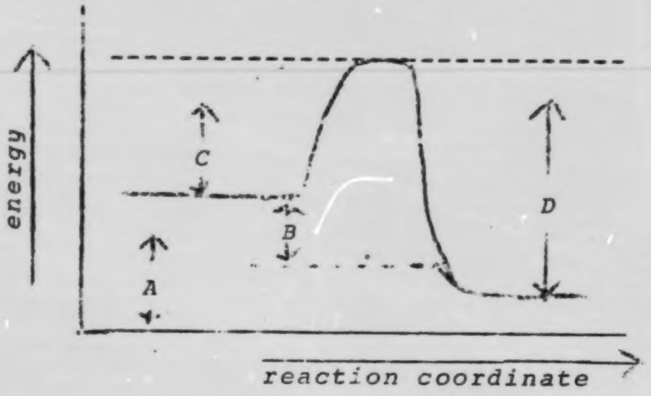


Figure 1

6. ________ In Figure 2, the rate determing step is best represented by letter: A. A; B. B; C. C; D. D.

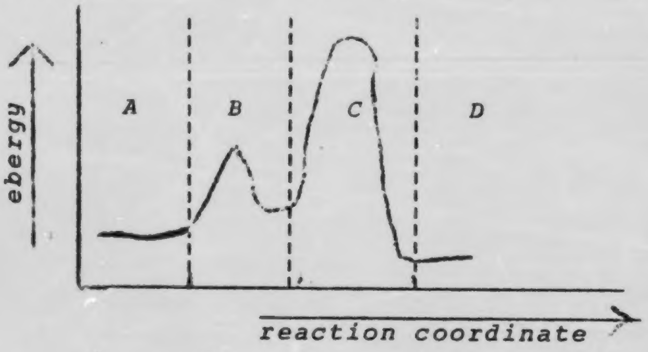


Figure 2

---

7. ________ Figure 3 represents a reaction that is most likely:
A. endothermic with a relatively high forward activation energy
B. endothermic with a relatively low forward activation energy
C. exothermic with a relatively high forward activation energy
D. exothermic with a relatively low forward activation energy

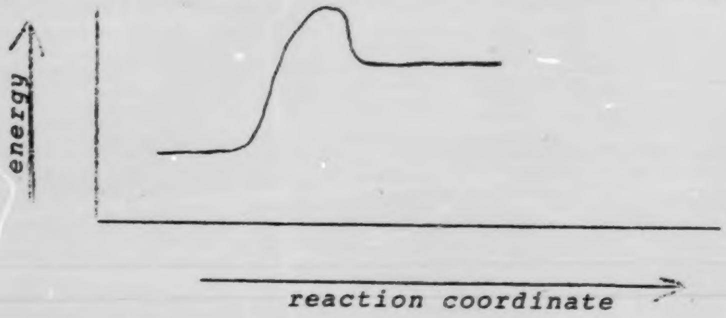


Figure 3

8. ________ Which best relates to why the nature of the reactants influences the rate of a chemical reaction? A. their size makes a difference; B. Their mass makes a difference; C. the kinds of bonds to be broken makes a difference; D. the ΔH makes a difference.

9. ________ Which best explains why increasing concentration increases reaction rate? A. the collisions become more effective; B. the average kinetic energy increase. C. the total number of collisions per unit time increases. D. the total number of collisions per unit time decreases.

10. ________ Which best explains why increasing the temperature increases reaction rate? A. the total number of collisions increases; B. the pressure of the system increases; C. more molecules have enough energy to collide effectively; D. the activation energy requirement is lowered.

11. ________ The function of a rate-accelerating catalyst is to: A. lower ΔH requirement; B. increase the number of collisions; C. raise the temperature of the system; D. lower the activation energy requirement.

12. ________ Which of the following is not true about catalysts? A. they might provide new, intermediate steps; B. they might lower the free energy of the reaction; C. they might provide a more favorable reaction surface; D. they might lower the activation energy.

---

13. ________ Each of the following statements applies to chemical equilibria except: A. Reactions stop, unless the system is disturbed. B. Reactions go on, but at equal rates. C. The value of the equilibrium constant is governed by temperature. D. Pressure is a factor that sometimes influences equilibrium conditions.

14. ________ For the reaction: $N_{2(g)} + 3H_{2(g)} = 2NH_{3(G)}$, the correct expression for the equilibrium constant K is:

A. $\dfrac{NH_3}{N_2 \; H_2}$ B $\dfrac{H_2{}^3 \; N_2}{NH_3{}^2}$ C. $\dfrac{NH_3{}^2 \; H_2{}^3}{N_2}$

D. $\dfrac{NH_3{}^2}{N_2 \; H_2{}^3}$

15. ________ The reason that pure solids and liquids are left out of the equilibrium expression is because: A. They are not important to equilibrium; B. Only substances that exert a pressure are important; C. Their concentrations are themselves constants.

16. ________ The value of the equilibrium constants shows that the products in a reaction are favored the most? A. $K = 1.0 \times 10^{-12}$; B. $K = 1.0 \times 10^{12}$; C. $K = 50$; D. $K = 0.002$

17. ________ Which of the following equilibrium constants shows that the products in a reaction are favored the most?

A. $K = 1.0 \times 10^{-12}$; B. $K = 1.0 \times 10^{12}$; C. $K = 50$; D. $K = 0.002$

18. ________ For the reaction: $NH_{3(g)} + H_2O_{(l)} = NH_4^+{}_{(aq)} + OH^-_{(aq)}$ the equilibrium constant $K = 1.8 \times 10^{-5}$. This means that at equilibrium: A. The concentration of molecules exceeds the concentration of ions; B. The concentration of ions exceeds the concentration of molecules; C. The concentration of ions equals the concentration of molecules; D. One cannot make a prediction about the concentration of molecules versus ions.

19. ________ For the general equilibrium system, A + B + C + D, which equilibrium constant most favors a high concentration of D?

A. 3×10^{-6}; B. 7×10^{-6}; C. $7 \times 10^{-}10$; D. 3×10^{-3}

---

20. _______ Which carbonate is the least soluble in water?

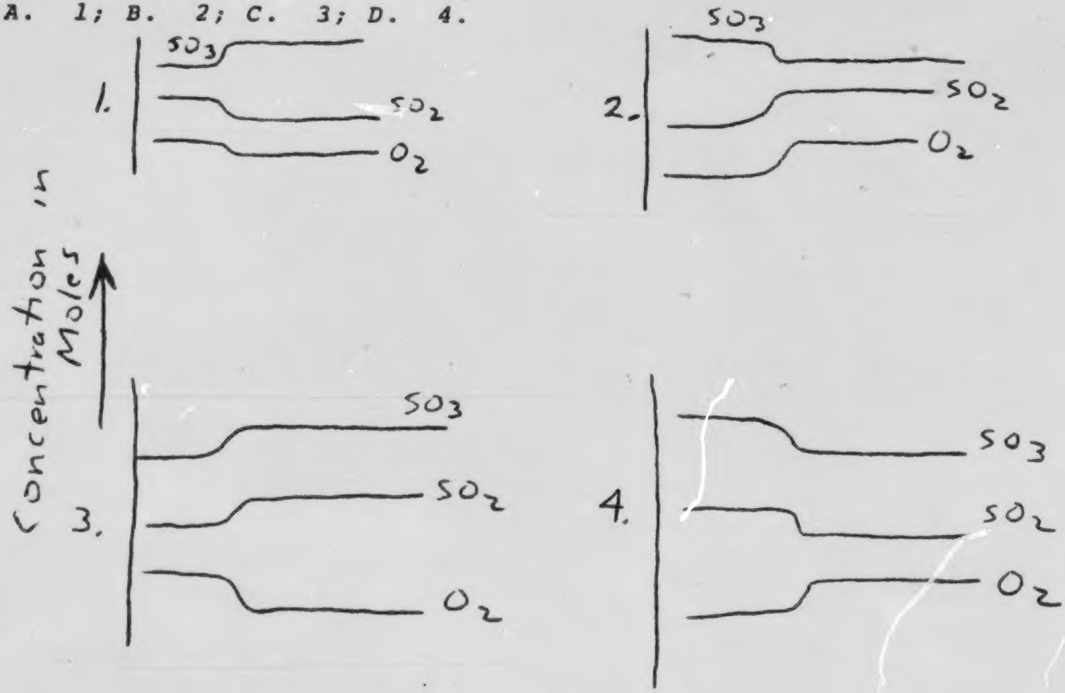
	FORMULA	K_{sp}
A.	$BaCO_3$	5×10^{-9}
B.	$CaCO_3$	4.8×10^{-9}
C.	$FeCO_3$	2×10^{-11}
D.	$PbCO_3$	1×10^{-13}

21. _______ Given the system: $2SO_{2(g)} + O_{2(g)} = 2SO_{3(g)} + 44$ kcal, at equilibrium, which change in the conditions would result in the largest increase in the concentration of SO_3?

A. increased pressure and increased temperature;
B. increased pressure and decreased temperature;
C. decreased pressure and decreased temperature;
D. decreased pressure and increased temperature.

22. _______ The system: $SO_{2(g)} + 1/4O_{2(g)} = SO_{3(g)}$, is at equilibrium. Which of the following diagrams (Fig. 4) correctly represents the effects of decreasing the pressure?

A. 1; B. 2; C. 3; D. 4.



---

23. ________ Given the system: $2SO_{2(g)} + O_{2(g)} = 2SO_{3(g)} + 46$ kcal, as the temperature of the system is lowered, the concentration of SO_3: A. increases; B. decreases; C. remains the same

24. ________ For the same system as in Question 23, if pressure is reduced, the concentration of SO_3 will: A. increase; B. decrease; C. remain the same

25. ________ Given the equilibrium system: $CaO_{(s)} + CO_{2(g)} = CaCO_{3(s)}$, as more $CaO_{(s)}$ is added, the equilibrium concentration of $CO_{2(s)}$: A. increases; B. decreases; C. remains the same

26. ________ The K_{sp} for AgCl is $1,6 \times 10^{-10}$. In a saturated solution of AgCl, the concentration of Ag^+ ion is:

A. $1.6 \times 10^{-10}\underline{M}$; B. $3.2 \times 10^{-10}\underline{M}$; C. $1.3 \times 10^{-5}\underline{M}$;

D. $2.6 \times 10^{-5}\underline{M}$

27. ________ Given the equilibrium system: $CO_{2(g)} + H_{2(g)} = CO_{(g)} + H_2O_{(g)}$, if the pressure is decreased, the equilibrium concentration of CO: A. increases; C. decreases; C. remains the same

28. ________ Raising the temperature of an equilibrium system: A. favors the exothermic reaction only; B. favors the endothermic reaction only; C. favors both the exothermic and endothermic reactions; D. favors neither the exothermic nor endothermic reactions.

29. ________ Raising the temperature of a chemical reaction: A. favors the forward rate only; B. favors the reverse rate only; C. favors both the forward and reverse rates; D. favors neither the forward nor reverse rates.

30. ________ Which of the following acids is the strongest?

	Acid	K_A
A.	HCN	4×10^{-10}
B.	HCO_3^-	4.8×10^{-11}
C.	$HASO_4^{-2}$	3×10^{-13}
D.	HS^-	1×10^{-14}

HAND IN TO INSTRUCTOR FOR HIS EVALUATION

NAME: ____________________
DATE: ____________________

TM-4 END OF MODULE TEST

Write the expression for the equilibrium constant for the Ostwald Process assuming both products and reactants are in gaseous state.

$$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$$

The reaction concerning dissociation of hydrogen sulfide gas to hydrogen and sulfur gases is:

$$2H_2S \rightleftharpoons 2H_2 + S_2$$

If a 4 liter vessel contains 2 moles H_2S, 0.4 mole H_2 and 1.6 moles S_2 what is the equilibrium constant?

Determine the pH of a solution with a hydrogen ion concentration of 3.5×10^{-4}.

Calculate the concentration of calcium ion and fluoride ion in a concentrated solution of calcium fluoride, CaF_2; when $K_{sp} = 4.00 \times 10^{-11}$.

Determine ΔH^o for the following reaction:

$$C_2H_5OH(l) + 3O_2(g) \qquad 2CO_2(g) + 3H_2O(l)$$

ΔH^o_f of ethyl alcohol + -65.9 Kcal/mole

ΔH^o_f of carbon dioxide = -94.1 Kcal.mole

ΔH^o_f of liquid water = -68.3 Kcal/mole

(Use back of sheet for answers.)

Tm-5 TAXONOMY

PURPOSE:

To aid the student of biological science in understanding the ever changing struggle that is TAXONOMY.

MATERIALS:

1. Ford, J. M. & J. E. Monroe. Living Systems, Principles and Relationships. Harper & Row, N.Y.
2. Bailey, L. H. How Plants Get Their Names. Dover Publ., N. Y. 181 p.
3. Sargent, C. S. Manual of Trees of North America. Dover Publ., N. Y.
4. Jacques, H. E. Living Things: How To Know Them. Wm. C. Brown Co., Dubuque, Iowa
5. Bold, H. C. Morphology of Plants, Harper & Row, N. Y.
6. Bold, H. C. The Plant Kingdom. Prentice-Hall, Englewood Cliffs, N. J.
7. Lawrence, C. H. M. An Introduction to Plant Taxonomy. MacMillan Co., N. Y.
8. Pool, R. J. Flowers and Flowering Plants. McGraw-Hill, N. Y.
9. Porter, C. L. Taxonomy of Flowering Plants. Freeman Co., San Francisco, Cal.
10. Russell, N. H. An Introduction to the Plant Kingdom. Mosby Co., St. Louis, MO.
11. Scagel, F. F. et. al. An Evolutionary Survey of the Plant Kingdom. Wadsworth Co., Belmont, Cal.
12. SSSA. Selected Papers in Soil Formation and Classification. SSSA Spec. Pub. No. 1. Soil Sci. Soc. of America., Inc., Madison, Wisconsin.
13. Knight, C. B., 1965. Basic Concepts of Ecology. MacMillan & Co. 468 p.
14. Smith, R. L., 1966. Ecology and Field Biology. Harper & Row, 686 p.

MATERIALS (cont.)

15. Holmes, A. Principles of Physical Geology. The Ronald Press Co. 1288 p.

16. Travis, R. B., 1955. Classification of Rocks. Quart. Colo. School of Mines, Vol. 50, No.1, 98 p.

17. Bowen, N. L. The Evolution of Igneous Rocks. Dover Publ. 322 p.

18. Sneath, P. H. A., 1957. Some Thoughts on Bacterial Classification. J. Gen. Microbiology 17:(184-200).

19. Kendrick, B. 1974. The Generic Iceberg. Taxon 23(5.6): 747-753.

20. Luedemann, G., 1969. Micromonospora Taxonomy. Adv. Appl. Micro. 11:101-133.

OBJECTIVES:

To enable a student to:

1. correlate between classificatory schemes utilized by biologists and microbiologists.

2. recognize the limitations of taxonomic schemes.

3. determine if and when an identification of an organism is complete for the problem at hand.

4. utilize classical morphological and modern numerical methods of taxonomy.

DATE STARTED: ______________________

TM-5 TAXONOMY INSTRUCTION CHECKOFF LIST

PACKET #1 - HOW THINGS ARE CLASSIFIED

Utilize programmed review to coincide with your reading from geology, ecology, biology, botany, zoology, pedology and microbiology. In this packet READ, JAQUES: LIVING THINGS, HOW TO KNOW THEM, Introduction and pages 1-16. Check your reading with the programmed review.

CHECK POINT ONLY ______________________

PACKET #2 - HOW THINGS ARE CLASSIFIED (cont.)

Read, FORD & MONROE, LIVING SYSTEMS, PRINCIPLES AND RELATIONSHIPS, "The Species Concept", pages 106-112. Note appendix pgs. 449-477. Check your reading with programmed review.
PACKETS #1, 2, and 3 WILL USE THE SAME PROGRAMMED REVIEW.

CHECK POINT ONLY ______________________

PACKET #3 - HOW THINGS ARE CLASSIFIED (cont.)

Read, BAILEY, L. H. HOW PLANTS GET THEIR NAMES, pgs. 1-83. Check your reading with programmed review. HAVE YOU KEPT UP WITH YOUR NEW TERMS AND NAMES ON 3" x 5" INDEX CARDS? DO YOU HAVE ANY NEW BOOKS STORED IN YOUR DATA STORAGE SYSTEM? HAVE YOU STARTED "KRITTER SHEETS" ON ANY NEW KRITTERS THAT YOU HAVE COME ACROSS IN YOUR READINGS? SHOW THESE MATERIALS TO YOUR INSTRUCTOR FOR CREDIT IN THESE THREE PACKETS.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #4 - SOIL CLASSIFICATION

Read, PART V - SOME CONCEPTS IN SOIL CLASSIFICATION PAGES 381-427, to include basic principles, problems, the Russian Approach, and the U. S. Classification System, in the SSSA's publication SELECTED PAPERS IN SOIL FORMATION AND CLASSIFICATION. Utilize the essay as described in Packet #4 to show your understanding of the problem.

DATE COMPLETED: ______________________
ESSAY: ______________________
3" x 5" INDEX CARDS: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #5 - GEOLOGIC CLASSIFICATION

Read, BOWEN, N. L. THE EVOLUTION OF IGNEOUS ROCKS - Chap. 1: The Problem of Diversity of Igneous Rocks and Chapter 18: Classification of Igneous Rocks. Also, read, Travis, R. B., CLASSIFICATION OF ROCKS - Introduction and Primary Division (to include pg. 2). Read, also, Holmes, A, PRINCIPLES OF PHYSICAL GEOLOGY - Chaps. 5 and 7, - Igneous Roakcs and Metamorphic Rocks and Granitisation. After finishing these reading assignments request the programmed review.

ROCK CYCLE COVER SHEET: ______________________
DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #6 THE CLASSIFICATION OF ECOSYSTEMS

Read, Knight, C. B. - BASIC CONCEPTS OF ECOLOGY, pgs. 228-235 and Smith, R. L. ECOLOGY AND FIELD BIOLOGY - Chap. 2 - The Ecosystem and the Community, pgs. 11-26. Complete vocabulary assignment and discuss findings with instructor.

VOCABULARY: ______________________
CRITIQUE: ______________________
DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #7 - BACTERIAL CLASSIFICATION

Read, Sneath, P.H.A., SOME THOUGHTS ON BACTERIAL CLASSIFICATION. Utilize the programmed review.

DATE COMPLETED. ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #8 - FUNGAL TAXONOMY

Read,, Kendrick, B. THE GENERIC ICEBERG, Taxon. 1974. Utilize programmed review.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #9 - ACTINOMYCETE TASONOMY

Read, Luedemann, G., MICROMONOSPORA TAXONOMY, pgs. 101-104, 106, 108, 122-131. UTILIZE PROGRAMMED REVIEW.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

REQUEST END OF MODULE ESSAY.

ESSAY: ______________________
DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________
GRADE: ______________________

TM-5 TAXONOMY
PACKET #1, 2, and 3 - PROGRAMMED REVIEW

---

1. The taxonomist tries to bring order from chaos by dealing with over _______ _________ species of plants and animals. In Jaques - LIVING THINGS - all creatures are divided into two great KINGDOMS: _______________ and ______________. The KINGDOMS are divided into __________ and the phyla then into ______________, _____________, ____________, ______________, and _____________.

---

2. In the text - LIVING SYSTEMS - ________ KINGDOMS are suggested rather than two. Single-celled procaryotae are placed in ___________. Single-celled or colonial, non-vascular creatures are placed in _____________. Those green plants which everyone has no difficulty in assigning to the old plant kingdom are classified as ______________, while easily recognized animals are ___________________.

1. one million
plant
animal
Phyla
Classes
Orders
Families
Genera
Species

---

3. While both zoologists and botanists use Capital Letters for the first letter of a ________________, e.g., Chlorella or Gregarina, some botanists (note in Bailey) use capitals for _______________, but zoologists never capitalized the first letter of a _______________. Whenever the binomial name of a creature is used in print it is _________________, but in writing or in typing it is _______________.

2. four
MONERA
PROTISTA
METAPHYTA
METAZOA

---

4. EXAMPLE: The common peach is named Prunus Persica by Bailey, but many botanists use Prunus Persica with a small letter for the species.

Prunus persica var. nuciperica is the __________. Note that varieties are not capitalized but are _______________________.

3. genus
species
species
italicized
underlined

---

5. EXAMPLE: Be sure to follow on page 14 & 15 the example Jaques has used in the keys. If you have difficulty see the instructor.

In Jaques Keys an error has been made. On page 17 he shows that the plant Kingdom is divided into DIVISION THALLOPHYTA and he does not show what other DIVISION is in the plant Kingdom. To clarify this most botanists place the phyta Bryophyta, Pteridophyta and Spermatophyta in the DIVISION EMBRYOPHYTA.

The Plant Kingdom may be divided into two major DIVISIONS: ______________________and__________________.

4. nectarine
underlined

---

5. Thallophyta
Embryophyta

6. The Division Thallophyta is divided into two ________; the Algae called ___________ and the fungi called ___________. According to the older taxonomic scheme of Jaques there are __________phyta in sub-division Phycophyta and only _________ in sub-division Mycophyta.	
7. List the phyla in the Algae using pages 154-155 in Jaques.	6. sub-divisions Phycophyta Mycophyta nine (9) three (3)
8. List the phyla within the Fungi.	7. Schizophyta Euglenaphyta Chlorophyta Chrysophyta Pyrrophyta Phaeophyta Rhodophyta Charophyta The Lichens
9. List the phyla which have vascular tissue,that is the EMBRYOPHYTA.	8. Schizmoycetes Myxothallophyta Eumycetes
10. Note the confusing differences between taxonomic groups between Jaques and Ford-Monroe. For example: While Jaques classes bacteria as ______________, Ford-Monroe places them in a new ________________ called ____________ and calls them ________________.	9. Bryophyta Pteridophyta Spermatophyta
	10. schizomycetes Kingdom Monera Schizophyta

11. FURTHER EXAMPLES: While in the older classification Chlorophyta, Chrysophyta, Phaeophyta and Rhodophyta are in DIVISION ________________, the new classification scheme places them in KINGDOM ________________ and the Pyrrophyta (Algae) are classed with Phylum __________________. While Jaques calls the blue-green algae ________________, Ford Monroe calls them ________________________.

12. In the older classification, the Slime Molds are all in __________________, but in the new classification they are in __________________.

13. In the older classification all protozoans are placed in phylum, ________________, but in the newer they are divided into four phyla: ______________, ______________, ______________, and ______________; all of which are in Kingdom __________________.

14. IN THE OLD CLASSIFICATION, Phylum Bryophyta is divided into only ________ classes: ______________ and ______________. (Note that Anthocerotales is in Hepaticae). In the new scheme Phylum Bryophyta is divided into ______________ classes, the third being ______________________.

15. In the old scheme there were two phyta covering the __________________ and __________________; in the new there is but ____________, the __________________. The orders of the older system are ___________ - _____________ of the new.

11. Thallophyta
Protista
Mastigophora
Schizophyta
Cyanophyta

12. Myxothallophyta
Myxomycetes

13. protozoa
Mastigophora
Sarcodina
Sporozoa
Ciliophora
PROTISTA

14. two (2)
Musci
Hepaticae
three (3)
Anthocerotae

15. Pteridophyta
Spermatophyta
one (1)
Tracheophyta
sub-phyla

THESE EXAMPLES ARE NOT MEANT TO CONFUSE, NOR IS THE STUDENT EXPECTED TO MEMORIZE THESE TAXONOMIC SYSTEMS. WHAT IS IMPORTANT IS TO RECOGNIZE THAT THE EXPERTS DO NOT AGREE ON HOW TO CLASSIFY CREATURES AND THAT TAXONOMY IS AN ALIVE AND CONTROVERSIAL PART OF SCIENCE.

TM-5 TAXONOMY

PACKET #4 - SOIL CLASSIFICATION: An unanswered and controversial area of TAXONOMY.

This packet is assigned in order to show the student that taxonomy is a problem in other areas of science and not only in microbiology, botany and zoology. After reading these short essays talk to other students and instructors. Gather your thoughts and ask your English instructor to aid in writing a critical essay concerning soil classification.

REFERENCE: Selected Papers in Soil Formation & Classification, SSSA Special Publication No. 1 Soil Science Society of America, Inc., Pub., Madison, Wisconsin.

VOCABULARY TO CONSIDER:

accessory characteristic

category

categorical rank

natural or universal classifications

edaphic profile

endodynamorphic

pedalfer

polypedon

accidental characteristic

level of abstraction

sociation

pedological profile

ectodynamorphic

pedocal

pedon

CARDS ON PEOPLE:

Cline

Marbut

Avery

Kubiena

Manil

Stephens

Dokuchaev

Glinka

Kellogg

Aubert-Duchaufour

Ivanova

Leeper

Muckenhausen

Stewart

Afanasev

Coffey

Kossovitch

Polunov

Rode

Rozov

Sibertsev

Tumin

Vysotskii

TM-5 TAXONOMY
PACKET #5 - CLASSIFICATION OF ROCKS - PROGRAMMED REVIEW

1. Rocks are made up of mixtures of __________. The old classification of rocks divides them into three groups: __________, __________, and ______________.	
2. Rocks which came from volcanoes or solidified from molten material have no flow pattern, contain primary minerals are usually easily classed as _____________. If minerals are present which the geologist knows show change in temperature, pressure, and chemical environment, and if flow patterns or stress patterns are present, then it is not difficult to recognize that the rocks have been subject to change and have metamorphosed....The geologist calls them ____________. If the rock shows evidence of having been broken up, carried, and redeposited by water, wind, ice or gravity fall he calls them ___________________.	1. minerals IGNEOUS METAMORPHIC SEDIMENTARY
3. Sometimes a metamorphic rock is buried deep and gradually completely remelts and looks like it is __________________. Sometimes igneous material flow between layers of sedimentary rock, breaking it into pieces and when it resolidifies it is a ____________. Sometimes volcanoes spew forth hot dry 'sandy' material which flows and when it solidifies it looks __________.	2. igneous metamorphic sedimentary
4. Geologists, like biologists, work in part with material which can ______________. Loose sediments progressively change into firm, indurated __________ rocks by consolidation and __________________. The changes are described as lithification or __________________. It is not always clear where diagenesis ends and ______________________ begins.	3. igneous hybrid sedimentary
5. As a result of ultra- ______________ a rock may begin to 'look' ____________. A rock can ______________ its metamorphic characteristics and become a ______________ rock without even melting.	4. change sedimentary cementation diagenesis metamorphism
	5. metamorphism igneous lose plutonic

6. Gneisses that look like mixtures of new granitic materials introduced into ______________ rock were called ______________ by Sederholm. Sub-volcanic granitization can change granodiorite to ____________________.	
7. Reproduce the Rock Cycle on page 192 in Holmes. Complete the series.....Diageneses Metamophism ______________________________ ______________________________.	6. older migmatites granophyre
8. Complete the series: Clay → Shale → ____________________ → ____________-____________ → ____________________ ____________________ → ____________ → granite.	7. metasomatic metamorphism granitization
9. The minerals of which rocks are ____________ are the expression of a ______________ to the conditions of their genesis. A genetic ______________ cannot transcend a classification based upon mineral ____________________.	8. phyllite mica-schist feldspathized schist migmatite
10. Geology has its problems in classifying rocks. As in the biological sciences the arguments develop around the problems of ________________. In practical systems they should be supported by findings from ________________. The findings of biochemists concerning DNA should not dramatically alter the work of the past ______________, nor should the work of ______________ change the classification system of geology.	9. composed response classification composition
	10. genesis genetics taxonomists petrologists

TM-5 TAXONOMY
PACKET #6 - CLASSIFICATION OF ECOSYSTEMS

Complete vocabulary study and discuss critically the attempts of ecologists to classify whole portions of our planet. Put vocabulary on 3" x 5" Index Cards.

VOCABULARY:

- *mosaic*
- *ecosystem*
- *habitat*
- *dominant*
- *characteristic*
- *abstract community*
- *global community*
- *oceanic community*
- *microstand*
- *aerial community*
- *continuum*
- *stratification*
- *geophyte*
- *cryptophyte*
- *epiphyte*
- *biotic community*
- *heterotrophic*
- *microhabitat*
- *exclusive*
- *ubiquitous*
- *concrete community*
- *continental community*
- *association*
- *mobile community*
- *specific diversity*
- *ecotone*
- *theorophyte*
- *chamaephyte*
- *phanerophyte*

TM-5 TAXONOMY

PACKET # 7 - BACTERIAL CLASSIFICATION - PROGRAMMED REVIEW

1. Classification can serve two purposes: (1) ____________ and (2) ____________. While enumeration has utility it does not increase the scientists ability to ____________ and to use observational materials.	
2. The underlying assumption in scientific classification (taxonomy) is that there is a ____________ order. The distinctive concept of ____________ classification is that it attempts to measure overall ____________, its distinctive value is in ____________. The overall similarity is measured by the number of ____________ features.	1. to enumerate (give names to or number things) to indicate SIMILARITIES (think about) classify
3. Theoretically every feature should have ____________ weighting. Only if a strong ____________ exists is the feature given heavier weighting, Different ____________ of taxa indicate roughly the degree of ____________. The first scientist to grapple with the problem of recognizing each creature as separate and yet in a group was ____________ in 1763.	2. natural measure similarity prediction similar
4. The fact that we have intermediate forms does not make ____________ impossible; it is simply an expression of the fact that ____________ is an infinite ____________ quantity. A 'taxon' is a group of ____________ with many features in common, but not necessarily possessing any particular ____________. Sneath calls these 'species-groups' or 'biotypes'.	3. equal correlation ranks similarity Adanson
5. "Division by Correlated Features" is proposed by Rogers and Sneath as a method which makes possible decisions within a major taxon. The family of bacteria which may be improperly broken into genera is the ____________. In classifying microbes it is important to avoid notions. We should be wary of ____________ keys (the very kind we use most often). Any tests which are used should be ____________.	4. classification relationship variable strains feature
	5. Enterobacteriaceae dichotomous standardized

6. It is especially important when attempting to classify an ________________ to utilize many __________________ and to apply ________________ ________________________.	
7. The development of 'natural' systems of classification can be followed in works of Bather (1927), Gilmour (1940) and Turrill (1942). Pioneers in this endeavor were: Linnaeus, Bauhin, Buffon, de Candolle, ______________, ________________ and ________________. The first taxonomist who conceived of using every feature impartially was Michel _____________________ (1763). One new concept of classification is that of Hayata (1921) which is the "___________________System". He arrays families side-by-side in order to avoid ___________ _____________. Evolution is of little value in bacteriology because there is no _________________ record.	6. organism tests (separate features, characteristics) statistical correlation
8. Numerical taxonomy does what Sneath requested, a large number of ____________________________ are compared using a _____________________.	7. deJussieu Cuvier Whewell Adanson Dynamic incorrect and/or premature pigeonholing fossil
9. In numerical taxonomy the computer is asked to ____________________ each strain with ________________ other and ____________________ the number of differences. Similarities are given numberical __________________ and this allows taxonomic __________________ to be defined.	8. characteristics computer
10. Sneath contends that where numerical taxonomy has been tried well, established creatures do not change ________________. "A bad ____________ is pulled apart by new _______________________".	9. compare every tabulate value rank
	10. genus classification discoveries

TM-5 TAXONOMY
PACKET #8 "THE GENERIC ICEBERG" - PROGRAMMED REVIEW

This article from TAXON, the major Journal of Taxonomy, is typical of articles which continuously appear in journals illustrating the enormous problems involved in properly and permanently classifying organisms. This particular aricle concerns FUNGI, in particular - HYPHOMYCETES.

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1. In the major reference, THE FUNGI - AN ADVANCED TREATISE, Kendrick and Carmichael found over ____________ generic names. Over 500 are valid, 600 were found to be ____________, Nomina dubia (Nomina confusa), illegitimate or ____________. This means that 600 names could be scrapped for good reason! This left ____________ names as ____________.	
2. Some of the 400 names are based upon work of Saccardo, von Hohnel, and other historically important ____________. Kendrick states that names assigned by these giants should be ____________ if no one has written about them since. Other genera should be discarded because they are very poor. Still other genera should be scrapped because the mycologists could not ____________ the features necessary to make ____________. Often the ____________ are inadequate. Kendrick and Carmichael would cut off these 'lost' genera at year ____________.	1. 1500 synonyms sterile 400 residue
3. The table supplied in this article indicates that errors are rampant up to ________; the authors imply that errors will exist up until ____________.	2. mycologists scrapped see drawings descriptions 1900
4. Since 1971 Kendrick has found ____________ 'new' genera in the ____________.	3. 1970 1980
	4. 70 literature

5. "One generic name is a later homonym, two appear to be invalidly _______________, and three are supplied to replace existing ______________. Only five have been _____________________.	
6. Kendrick estimates that about ___________ new genera are being added per ______________.	5. published homonyms validated
7. Kendrick suggests a _______________, of new taxa while we attempt to cope with those already in existence. If mycologists insist on naming more, he asks for adequate __________________ material. This should be placed in ____________. He also wishes.___________________________,	6. 20 year
8. To students this article should stress the need to carefully collect _______________. Each portion of plant, animal or microbe must be ______________ and ___________________. If at all possible a portion of specimen should be _____________________.	7. moratorium type herbaria illustrations
9. What applies to fungi also applies to lichens, algae, seaweeds, slime molds.....in short, in all material subject to study, especially "kritters' classified. What else must be done to avoid mistakes?	8. data inspected drawn (illustrated) maintained
10. Who wrote "The Future of Taxonomic Entomology"?	9. Consult the vast literature Send samples to other experts
	10. Check bibliography. This should have been stored in your DATA STORAGE SYSTEM!

TM-5 TAXONOMY
PACKET #9 MICROMONOSPORA TAXONOMY - PROGRAMMED REVIEW

This article on Micromonospora is aa much philosophical as it is scientific and taxonomic. It is assigned not to produce experts on actinomycetes, but to display the problems which are extant in microbiology. This programmed review should bring out typical problems the taxonomists must fact.

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1. What do microbiologists know about the natural relationships beween Micromonospora species? ________________. Do chemists know more about elements? ________________	
2. What do microbes (and other living creatures) perform which makes classification more diffisult than in chemistry, astronomy or geology? ________ ________________________________.	1. almost nothing Chemists deal with inanimate objects---relatively easy to classify.
3. Scientists classify soils and ecological niches; what do these workers have in common with microbiologists? ________________________ ____.	2. They are alive. They grow, adapt and mutate.
4. How can the microbiologist tell that an actinomycete has either adapted to environmental change or has mutated? ________________________ ____.	3. Both deal with change. Soils and ecological systems evolve, adapt and change identity.
5. What is an unnatural isolate? ______________ __________________. What two factors cause this effect? ______________________________	4. It can lose morphological characteristics, but it does not gain characteristics of another actinomycete.
	5. An unnatural isolate is an isolate in the laboratory that during its adaptive phase can lose the characteristics that it once had. Strain resistant to lysis or 'out-running' of its phage.

6. Why have so few micromonosporae been found? __________. Are micromonosporae rare? ______________________________ ______________________________.	
7. Who first proposed the genus Micromonospora? __________. Who first found that soil was a natural habitat for members of this genus? __________. What famous microbiologist erred in calling M. gallica a member of Actinomyces? __________. Two famous Russian soil microbiologists worked with micromonospora. Who are they? __________ __________.	6. insufficient incubation unfamiliarity of microbiologists with what to look for. THEY ARE COMMON!!!!!
8. Umbreit and McCaoy (1941) found micromonosporae in a new habitat which was __________. The antibiotic 'micromonosporin' was thought to have been obtained from M. fusca but more likely was obtained from M. __________. Sebold and Prevot found that their 'termite' actinomycete, M, acetoformici utilized __________ as a carbon source. Members of what other genera may contribute micromonosporae? __________ and __________. What other antibiotics are produced by members of this genus? __________, __________, __________, and __________.	7. Orskov (1923) Jensen (1932) Erikson (1935) Kriss (1941) Krasilnikov (1941)
9. What may occur after many subcultures are prepared? __________. Because micromomosporae do not have appreciable aerial mycelia what method is used to study their micromorphology? __________.	8. Lacustrine deposits chalcea $CaCO_3$ (lime) Actinomyces Nocardia actinomycin everninomycin halomicin nocardorubin
	9. Transfer to transfer variation Direct staining of sporulating colonial mycelia.

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10. The final speciation of the microsporae depends upon two techniques: ______________________ and ________________. Hopefully it may be noted that classification of actinomycetes, and indeed, most microbes, requires the use of __________________ techniques, and a great amount of skill and __________________________________.

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10. Good spore and sporophore preparation in light microscope.

Electron microscopy to resolve detail of sporophore.

many

patience

HAVE YOU PUT ANY NEW NAMES AND TERMS ON 3" x 5" INDEX CARDS?

HAVE YOU STARTED 'KRITTER SHEETS' ON ANY NEW CREATURES THAT WERE MENTIONED IN THIS ARTICLE?

IS YOUR DATA STORAGE DECK UP TO DATE?

FOR THE END OF MODULE TEST IN THIS MODULE YOU WILL WRITE AN ESSAY USING EXAMPLES FROM GEOLOGY, SOILS, BOTANY, ZOOLOGY, AND MICROBIOLOGY SHOWING THAT YOU UNDERSTAND THE PROBLEMS INVOLVED IN CLASSIFYING SOMETHING WITH CERTAINTY. THE ESSAY SHOULD BE LESS THAN FIVE (5) TYPEWRITTEN PAGES. IT WILL BE CORRECTED FOR ENGLISH, PUNCTUATION, COHERENCE, AS WELL AS CRITICAL COMMENT.

TM-6 BASIC LABORATORY TECHNIQUES

PURPOSE:

To aid the student in developing basic chemistry laboratory skills.

MATERIALS:

1. Communication Skills Corporation Slide-Tape Presentations.

#811 - Common Laboratory Apparatus

#812 - Pipetting Techniques

#813 - Titration Techniques

#814 - Preparing Solutions

#815 - pH Preparation

#819 - Colorimetric Analysis

Communication Skills Corporation, P. O. Box 684, Fairfield
Connecticut, 06430

2. American Institute of Biological Sciences

#8118 - How to measure the Transmittance or Absorbance of Solutions with a Simple Spectrophotometer

Communication Skills Corporation, P. O. Box 684, Fairfield,
Connecticut 06430

3. O'Connor, R. Fundamentals of Chemistry, 2nd Ed., Harper & Row

4. Sisler, H. H., Vanderwerf, C. A. & Davidson, A. W. College Chemistry, 3rd Ed., MacMillan Co.

5. Skoog, D. A. and West, D. M. Fundamentals of Analytical Chemistry. Holt, Rinehart & Winston.

6. Common laboratory equipment to match packets: burettes, volumetric flasks, pH meter, Spectrophotometer cuvettes.

OBJECTIVES: To enable student to:

1. Use test tubes, beakers, volumetric flasks, the Bunsen burner and other basic laboratory tools and glassware.

2. Perform a titration

3. Prepare percent, molar, molal and normal solutions

TM-6 BASIC LABORATORY TECHNIQUES

OBJECTIVES: (cont.)

4. Measure pH

5. Compare concentrations using colorimeter

6. Determine transmittance and absorbance using a spectrophotometer

DATE STARTED: ____________________

TM-6 BASIC LABORATORY TECHNIQUES INSTRUCTION & CHECKOFF SHEET

In this module you will become familiar with a few basic laboratory techniques. Go over the slides and tapes and perform the tasks outlined.

PACKET #1 - #811 - COMMON LABORATORY APPARATUS

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #2 - #812 - PIPETTING TECHNIQUES

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #3 - #813 - TITRATION

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #4 - #814 - PREPARING SOLUTIONS

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #5 - #815 - pH MEASUREMENTS

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #6 - #819 - COLORIMETRIC ANALYSIS

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #7 - #8118 - HOW TO MEASURE THE TRANSMITTANCE OR ABSORBANCE OF SOLUTIONS WITH A SIMPLE SPECTROPHOTOMETER

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

END OF MODULE TEST ______________

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

TM-6 BASIC LABORATORY TECHNIQUES
PACKET #1 - #811 - COMMON LABORATORY APPARATUS - REVIEW EXERCISE

AFTER REVIEWING SLIDES AND CASSETTES, DO THIS REVIEW EXERCISE AND HAND IN TO INSTRUCTOR FOR HIS EVALUATION.

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1. Two grades of chemical reagents are __________ ________________ and ________________________________.

2. What three things does a label on a chemical reagent bottle tell you?

   A.

   B.

   C.

3. The accuracy of a triple beam balance is ____________________________.

4. Can a volumetric flask be used to measure variable volumes? ____________.

5. Name two types of pipets and explain how they are different.

   A.

   B.

6. A buret can be used to deliver liquid volumes. How do you measure the volume delivered?

7. The process of separating a liquid from a solid is called ________________. The separated solid is called ____________________, the separated liquid is called ______________________________.

8. The type of filter funnel which uses filter paper and suction is called a ________________________.

9. The type of filter device used for weighing precipitates is called a ____________________ ____________________ __________________.

10. The ____________________ is an alternative to filtration, from which the precipitate is recovered as a tightly packed solid at the bottom of a tube.

11. Samples which are non-flammable can be heated with the ____________________ ________________. Flammable samples should be heated in a ____________________ using a ____________ __________________.

NAME: ________________________________

DATE: ________________________________

SECTION ONE:

1. If you were required to dispense 10 ml of liquid into each of ten containers, which type and size pipet would you use?

2. Indicate on a drawing how the liquid level or meniscus would appear if you were measuring or dispensing 5.3 ml from a measuring pipet.

3. What size and type of pipet would you use for No. 2?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 11.

SECTION TWO:

1. If you were filling a pipet by mouth, and the tip came out of the liquid, what would happen?

2. Before you use a pipet to dispense your sample, you should be sure that it is ____.

3. What would happen if the liquid is allowed to rise up into the bulb?

4. Once you have removed the filling bulb, how can you be sure that there is a good seal between the mouth of the pipet and your finger?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 20.

SECTION THREE:

1. Why should a pipet be rinsed before you use it to dispense your sample?

2. When filling the pipet, you should bring the liquid level up to the first graduation mark and seal the top. Is this true or false?

3. When a drop of liquid remains on the tip of the pipet, you must remove it before delivering the sample. Is this true or false?

4. When using a transfer pipet, the liquid remaining in the tip should be expelled with a rubber bulb. Is this true or false?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 30.

TM-6 BASIC LABORATORY TECHNIQUES

PACKET #2 - #812 - PIPETTING TECHNIQUES - FINAL EXERCISE

When complete hand in to your instructor for his evaluation.

1. Name the two general classes of pipets. ______________________ and ____________________.

2. Which technique do you think would be more accurate? Why?

   A. dispensing 10, 1 ml aliquots from a 10 ml measuring type pipet.

   B. dispensing 10 separate 1 ml samples from a 1 ml transfer pipet.

3. After dispensing a volume of liquid from a pipet that is graduated to the tip, would you A. blot the tip with a tissue; B. touch the tip to the side of the container and allow it to drain or; C. blow out the remaining liquid using a bulb?

4. If the meniscus is uneven, the pipet is probably ______________________.

5. If after filling and sealing the pipet, the liquid level slowly drops, the problem may be:

   A. too large a pipet for the volume being delivered

   B. a crack in the tip

   C. a crack or chip in the top

   D. failure to use silicone grease to seal the top

6. If you had an unknown amount of liquid in a container, could you determine its volume using a pipet? Why?

NAME: ______________________________

DATE: ______________________________

TM-6 BASIC LABORATORY TECHNIQUES
PACKET #3 - #813 - TITRATION - FINAL EXERCISE

WHEN YOU HAVE COMPLETED THE EXERCISE, GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

1. A volumetric flask is used to make up ____________________ solutions. A standard solution is one of known ______________________.

2. What are the ingredients of the cleaning solution described in this program?

3. The buret stopcock can be made either of ___________ or ___________. The _____________ type requires lubrication. The lubricant should not contain any ___________________________.

4. The procedure for cleaning the buret is shown in the program. To fill the buret with cleaning solution you first ____________ the stopcock. Then you apply _______________ with the aspirator. Only then do you _______________ the stopcock. You allow the liquid to rise to a level about ______________ from the stopcock. Then you _______________ the stopcock and remove the __________________.

5. A dirty buret can be identified by an uneven ___________ and __________ of liquid inside the barrel.

6. The chemical signal used in titration to give the end point is the ____________________ of an indicator.

7. The technique of splitting a drop is illustrated in the program. Explain how you split a drop.

8. You know you have reached the ______________ when the color remains unchanged for at least ___________ _________________.

9. Draw the position of the meniscus on a drawing for a value of 23.85 ml.

10. Generally you repeat the analysis _____ more times and check to see if there is good agreement between readings. For a first attempt agreement of __________ ml between successive readings is considered reasonable precision, but accomplished lab workers can obtain precisions of better than _________ part per 1000.

11. Standard solutions must often be protected from ___________ constituents, such as __________ and ___________. Either store them in an ________________ atmosphere or in a ____________ _____________ ______________.

NAME: ______________________________

DATE: ______________________________

TM-6 BASIC LABORATORY TECHNIQUES
PACKET #4 - #814 - PREPARING SOLUTIONS - REVIEW EXERCISE

WHEN YOU HAVE COMPLETED THIS EXERCISE, GIVE THE ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION AND PLACEMENT IN YOUR FOLDER.

1. A solution must have a fixed amount of solute and solvent which cannot be varied. True or False?

2. When no further solute will dissolve in a solution, it is said to be ___________________.

3. Three terms for expressing the concentration of a solution are _____________, ___________________, and ___________________.

4. A 1M solution contains one ____________ of ____________ per liter of solution.

5. What is the normality of: A. 1 Molar solution of HCl and B. 1 Molar solution of H_2SO_4?

A. ______________________________

B. ______________________________

6. For most solutes, increasing the temperature _____________ the rate at which solute dissolves in solution.

7. If you were asked to prepare 500 ml of a 1 Molar solution of potassium dichromate ($K_2Cr_2O_7$, mol. wt.: 294.21), how many grams of solute would you add to 500 ml of solution?

8. If you dissolved 200 mg of NaOH in distilled water to make 1 liter of solution, what would be the Molarity of the solution?

9. In preparing acid solutions by dilution, what general rule must you always follow?

10. How many milliliters of concentrated HCl would be needed to prepare 1 liter of 5 N HCl? (Reagent grade concentrated hydrochloric acid has a density of 1.18 g/ml and contains 38.0 g of HCl per 100 g of solution; g mol. wt. of HCl = 36.457g/mol.)

NAME: ______________________________

DATE: ______________________________

TM-6 BASIC LABORATORY TECHNIQUES
PACKET #5 - #815 - pH MEASUREMENTS - FINAL EXERCISE

When you have completed this exercise give your answers to your instructor for his evaluation.

1. A base is a substance which can ________________ a hydrogen ion to form __________________.

2. In the dissociation of the water molecule, the Ion Product, K_W = __________ x ____________. Its value at 25°C is ______________.

3. The Ion Product for water is a _______________ at 25°C. At 100°C, K_W for water is ________________.

4. What is the hydrogen ion concentration of a 0.01 M solution of HNO_3?

5. What is the hydrogen ion concentration of a 0,015 M solution of NaOH?

6. pH is defined as the ______________ logarithm of the hydrogen ion concentrated.

7. Calculate the pH of the following solutions:

$[H^+] = 1 \times 10^{-3}$

$[H^+] = 10 \times 10^{-4}$

$[OH^-] = 1 \times 10^{-7}$

$[OH^-] = 1 \times 10^{-13}$

$[H^+] = 3 \times 10^{-5}$ (log 3 = 0.4771)

8. The potential of the calomel reference electrode is ____________ of hydrogen ion concentration.

9. The calomel electrode contains Hg, Hg_2Cl_2 and is filled with __________ solution.

10. When not in use, the two electrodes of the pH meter should be kept in __________________________.

11. The glass electrode responds to changes in ___________ concentration.

12. The glass electrode has a thin _______________ bulb at its tip which is filled with 0.1 M _________________________.

13. Where would the temperature compensator control be set if the pH meter is standardized with buffer solution at 25 C, and the sample solution to be measured is at 30 C?

---

14. What control is used to set the meter pointer to zero?

15. Is water a buffer solution? Explain.

16. To make a pH measurement at pH 5.0, what pH would you choose to standardize the pH meter?

17. If you were adjusting the pH of a solution from 6 to 9, at what pH would you standardize the meter?

18. What are two possible sources of error in making pH measurements with a pH meter?

19. Can you use pH paper for measuring a pH of 5.1? Why?

20. Are pH measurements using a pH meter with standard electrodes accurate at all readings? Explain your answer.

NAME: ______________________________

DATE: ______________________________

TM-6 BASIC LABORATORY TECHNIQUES
PACKET #6 - #819 - COLORIMETRIC ANALYSIS - SELF QUIZZES

WHEN YOU HAVE COMPLETED THIS EXERCISE GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

SECTION ONE:

1. The distance from the crest of one wave to the crest of the next is called the ________________.

2. The number of waves passing a fixed point in one second is called the ______________________________.

3. The expression relating wavelength, frequency and velocity for a wave motion is ______________________________.

4. The frequency of a light beam is 4.00 x 10^{14} Hz. Calculate its wavelength in nanometers.

5. The energy of a photon equals Planck's constant (h) x _______________.

6. The condition for photon absorption by an atom or molecule is _____________.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 15.

SECTION TWO:

1. Define: % Transmittance (%T) =

Absorbance (A) =

2. The Beer-Lambert Law states: $A = \varepsilon bc$. What is each term in this equation?

A = _________________________

ε = _________________________

b = ________________________

c = _________________________

3. Use the formula A = 2 - log (%T) to calculate the absorbance of a solution with %T = 40. (Log 4 = 0.602.)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 21.

SECTION THREE:

1. Describe the function of the zero control. How is it set?

2. How is the operating wavelength selected?

3. What is the purpose of the 100% control? How is it set?

4. When the value you read on the spectrophotometer scale is in %T, how is it converted to absorbance?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 39.

WHEN YOU HAVE COMPLETED THIS EXERCISE, GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

1. What are the % T and A readings on the meter set up in the laboratory?

% T = ____________________

A = ____________________

2. The absorbance of a series of solutions of alkaline potassium chromate was measured at 370 nm. The data is recorded below. Plot a graph of absorbance versus concentration on a piece of graph paper. Does this solution obey the Beer-Lambert Law?

ABSORBANCE AT 370 nm	CONCENTRATION OF ALKALINE POT. CHROMATE (g/l.)
0.21	8.51×10^{-3}
0.52	21.07×10^{-3}
0.81	32.82×10^{-3}
1.15	46.60×10^{-3}
1.24	50.24×10^{-3}

3. The absorbance of an unknown potassium chromate solution was measured and found to be 0.61. Use your standardization graph to determine the concentration of this solution.

CONCENTRATION OF SOLUTION = ________________________________

NAME: ______________________________

DATE: ______________________________

TM-6 BASIC LABORATORY TECHNIQUES
PACKET #7 - 18118 - HOW TO MEASURE THE TRANSMITTANCE OR ABSORBANCE OF SOLUTIONS WITH A SIMPLE SPECTROPHOTOMETER - FINAL EXERCISE

WHEN YOU HAVE COMPLETED THIS EXERCISE, HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION.

1. Why does a solution of copper sulfate appear blue when viewed in white light?

2. The transmittance of a sample equals the ratio of ____________ over ______________. The absorbance, A, euals the log of ______________ over __________________.

3. % T __________ with increasing sample concentration A increases with ______________ sample concentration.

4. What is a standard curve and how is it used?

TRUE-FALSE

1. _____ To set 100 % T, shut off all light to the detector and set the meter to 100 with the 100% control.

2. _____ To set 0%T, place the blank solution in the sample compartment and adjust the 0 control to 0.

3. _____ Wavelength adjustment is only an approximate setting. Therefore, it's not necessary to be precise when setting this control.

4. _____ The blank is usually a dilute solution of the sample.

5. _____ A plot of absorbance vs. concentration is called a standard curve.

6. _____ A plot of absorbance of %T vs. wavelength is called an absorption spectrum.

7. _____ Samples which have no color do not absorb light.

8. _____ The Beer-Lambert Law states that A = abc, where b is the cell path length, c is the sample concentration, and a is a constant.

9. _____ The spectrophotometer measures the amount of light absorbed by the sample.

10. _____ Each time a new wavelength is selected, you must reset the 0 and 100%T controls.

NAME: ______________________________

DATE: ______________________________

TM-6 BASIC LABORATORY TECHNIQUES
END OF MODULE TEST

WHEN FINISHED WITH THESE QUESTIONS HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION AND CREDIT FOR THE MODULE

1. How are test tubes classed?

2. What are the graduations on a beaker used for?

3. What are the precautions necessary when preparing a molar solution using a volumetric flask?

4. What is a 'policeman'?

5. What precautions must be used during titration?

6. Describe how to prepare 1,0 molar, molal and normal solutions for hydrochloric acid.

7. What precautions must be taken to avoid error in colorimetric analyses?

8. How does the analyst choose the wavelength required for maximum absorbance?

9. What situations may cause interference?

10. How is pH meter 'adjusted'?

NAME: ____________________

DATE: ____________________

TM-7 CHEMICAL BONDING

PURPOSE:

To lead the student through the theoretical and mathematical development of chemical bonding theory.

MATERIALS:

1. Leicester, H. M. The Historical Background of Chemistry. John Wiley & Sons.

2. Companion, A. L. Chemical Bonding. McGraw-Hill Co.

3. Barrow, G. M. The Structure of Molecules. W. A. Benjamin, Inc.

4. Heslop, R. B. & Robinson, P. L. Inorganic Chemistry. Elsevier Pub. Co.

5. Coulson, C. Valence. Oxford Inoversoty Press.

6. Pauling, L. The Nature of the Chemical Bond. Cornell University Press.

7. Runquist, O. A., Creswell, C. J. & Head, J. T. Chemical Principles: A Programmed Text. Burgess Pub. Co.

8. Communications Skills Corporation Slide-Tape Presentations

#861 - BONDING - ATOMS OF THE SAME ELEMENT - THE METALLIC BOND.

#862 - BONDING - ATOMS OF THE SAME ELEMENT - NONMETALS: THE COVALENT BOND.

#863 - BONDING - ATOMS OF DIFFERENT ELEMENTS - METALS AND NONMETALS: THE IONIC BOND.

#864 - BONDING - ATOMS OF DIFFERENT ELEMENTS - NONMETALS: COVALENT COMPOUNDS.

#865 - ELECTRONEGATIVITY, POLAR COVALENT BONDS, POLAR MOLECULES, HYDROGEN BONDS AND COORDINATE COVALENT BONDS.

Communication Skills Corporation, P. O. Box 684,
Fairfield, Conn. 06430

OBJECTIVES: To enable the student to:

1. Construct molecular structural formulae

2. Use single, double and triple bond symbols

TM-7 CHEMICAL BONDING
OBJECTIVES: (cont.)

3. Understand hydrogen bonding and van der Waals forces.
4. Utilize electronegativity information to predict chemical reactions.
5. Prepare an electronegativity addendum to the Periodic Chart.

TM-7 CHEMICAL BONDING

DATE STARTED: ____________________

INSTRUCTION & CHECK OFF LIST

INTRODUCTION: This module concerns an in-depth study of the nature of the chemical bond. Reference should be made to Sienko & Plane and the paperback, Companion, Chemical Bonding, during the study of this module. It is suggested that Sienko & Plane be reviewed first and the Preface and Chapter I of Companion be read as a start into this work.

PACKET #1 - Read Leicester, Chapter XVI. Request self-correcting quiz.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #2 - Review tapes and slides in the CSC series #861 - CHEMICAL BONDING-METALS. Take self-quiz at end of tape.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #3 - Read Runquist, Chapter 4, Chemical Bonding - A Programmed review.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #4 - Review tapes and slides in the CSC series #862 - BONDING OF NON-METALS & COVALENT BOND. Take self-quiz at end of tape and hand in to instructor.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #5 - Review tapes and slides in the CSC series #863 - BONDING OF DIFFERENT ELEMENTS: THE IONIC BOND. Take self-quiz at end of tape and hand in to instructor.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #6 - Review tapes and slides in the CSC series #864 - OTHER COVALENT BONDS. Take-self quiz at the end of tape and hand in to instructor.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #7 - Review tapes and slides in the CSC series #865 - ELECTRONEGATIVITY. Take self-quiz at end of tape and hand in to instructor.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

TM-7 CHEMICAL BONDING
INSTRUCTION & CHECK OFF LIST (cont'd.)

PACKET #8 - Utilize your texts and/or the wall chart to show on your periodic table the electronegativity of the elements. Submit revised chart for inspection by the instructor.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #9 - Reread and conquer Companion's book, Chemical Bonding. Be sure to list all scientists and philosophers on 3" x 5" cards. Prepare for end-of-module exam. Submit questions and answers to chapters 1 through 5 of this book completed in detail. Hints in the book are correct but ARE NOT complete. Submit materials to instructor.

3" x 5" cards ________________________
Answers to questions _________________
DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

DO YOU HAVE DATA STORAGE CARDS FOR THE MATERIALS IN THIS MODULE?

REQUEST END-OF-MODULE TEST. GRADE: ____________

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

TM-7 CHEMICAL BONDING
PACKET #1 - SELF CORRECTING QUIZ

MATCHING

1. ________ Richter
2. ________ Proust
3. ________ Berthollet
4. ________ Higgins
5. ________ Dulong-Petit
6. ________ Graham-Liebig
7. ________ Avogadro
8. ________ Berzelius
9. ________ Wollaston
10. ________ Prout

A. prepared $CuCO_3$ both naturally and by synthesis and proved law of constant composition.
B. the product of the atomic weight and specific heat for an element is constant.
C. the atomic weights of elements are whole multiples of the atomic weight of hydrogen
D. first statement of the law of mass action: compounds of indefinite composition named after him
E. the nature of acids: ortho-, pyro-, metaphosphoric acids
F. equal volumes of different gases contained the same number of particles (if temperature and pressure are kept constant)
G. table of atomic weights; 1814
H. coined the term: STOICHIOMETRY (use of the law of constant proportions_...... first table of equivalents
I. anticipated Dalton's work and developed the ideas of atomic combination and law of multiple proportions in 1789
J. table of equivalent weights

TM-7 CHEMICAL BONDING
PACKET #2 - CSC #861 - BONDING. ATOMS OF THE SAME ELEMENT.
THE MEALLIC BOND.

SECTION ONE:

1. ____ Metallic elements occupy what part of the periodic table? (a) left half, (b) all except the upper right section, (c) center portion.

2. ____ The elements that are best electrical conductors are: (a) non-metals, (b) metalloids, (c) metals.

3. ____ The property of having the capability of being drawn out into a wire is called: (a) ductility, (b) thermionic emission, (c) malleability.

4. ____ Which class of elements has the greatest insulation properties (heat and electrical)? (a) metals, (b) metalloids, (c) non-metals.

5. ____ Compared to non-metals, metallic elements attract their electrons: (a) stronger, (b) weaker, (c) about the same.

6. ____ Which of the following elements attracts its electrons strongest? (a) Mg, (b) Si,, (c) S.

7. ____ Under comparable conditions which elements reflect light most completely? (a) metals, (b) metalloids, (c) non-metals.

8. ____ Which of the following elements emits electrons most readily when heated? (a) Rb, (b) Pd, (c) I.

WHEN YOU HAVE COMPLETED THIS EXERCISE, RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION TWO: TRUE - FALSE

1. ____ Atoms of metallic elements are closely packed together in some definite (crystalline) order or arrangement with respect to one another.

2. ____ All the electrons of metallic atoms are free to move about in the space between the atoms.

3. ____ When sufficiently near one another there will always be some electrical interaction between atoms of any element.

4. ____ Atoms of metallic elements are bound together in a solid by their mutual attraction for the mobile negative valence electrons.

5. ____ The valence electrons can move about in the space between the kernels of the metal atoms because they are not strongly bound to any one atom and because there are vacant orbitals accessible to them.

6. ____ The atomic kernels do not move at all, only the electrons are capable of movement.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 19.

SECTION THREE: TRUE-FLASE

1. ____ Metals reflect all wave lengths of visible light because some of their electrons have a wide range of possible energies and are capable of absorbing and re-emitting the light energy.

2. ____ Electrical conductivity in metals is due to the mobility of the positive lattice ions.

3. ____ Metals that are good electrical conductors should also be good heat conductors.

4. ____ All the metallic elements emit electrons with equal ease.

5. ____ Metals are ductile and malleable because when their atoms are forced to change positions the electrons can also move to continue to bind atoms together,

WHEN YOU HAVE COMPLETED THIS EXERCISE, RESTART THE TAPE AND ADVANCE TO FRAME 29.

SECTION FOUR: TRUE-FALSE

1. ____ Na is more malleable than Mg.

2. ____ Rb has a higher ionization potential than K because its atoms are much larger.

3. ____ Cu is a better electrical conductor than Ag.

4. ____ Cu is a poorer conductor of heat and electricity than Fe because it is farther to the right in their period.

5. ____ Lithium (Gp IA) and Beryllium (Gp IIA) have fewer characteristic metal properties than other members of their groups.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 34.

TM-7 CHEMICAL BONDING
PACKET #2 - CSC #861 - REVIEW QUIZ

TRUE-FALSE

1. ____ Calcium (Gp IIA) has a greater tensile strength than Potassium.

2. ____ Potassium has a longer liquid temperature range than Gallium.

3. ____ The free electrons in metals move faster on average at higher temperatures, so the conductivity of metals increases with increasing temperatures.

4. ____ Thermionic emission means electron emission from very hot metals.

5. ____ Tendency to electron loss is the most characteristic property of metals.

6. ____ Metalloids are elements with intermediate properties between metals and non-metals.

7. ____ Within a period, the increase in effective nuclear charge, causes an increase in metallic properties.

8. ____ Within a group, increase in atomic size causes an increase in tendency to electron loss.

EXPLAIN WHY ALL THE TRANSITION AND INNER TRANSITION ELEMENTS ARE METALS.

HAND IN TO INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________________

DATE: ______________________________

TV-7 CHEMICAL BONDING

PACKET #4 - #862 - BONDING - ATOMS OF THE SAME ELEMENT - NON-METALS: THE COVALENT BOND SELF QUIZZES

SECTION ONE: TRUE-FALSE

1. ____ All the metallic elements tend to gain electrons and form negative ions, whereas the non-metallic elements tend to lose electrons and become positive ions.

2. ____ All the noble gases are chemically unreactive and form no chemical compounds.

3. ____ Metals have low ionization potentials aqd high electron affinities.

4. ____ When the same element can exist in different physical forms, the phenomenon is called allotropy.

5. ____ Bromine is the only liquid non-metal at room temperature and pressure.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 10.

SECTION TWO:

FILL IN THE MISSING WORDS:

Only __________ electrons are used in chemical bonding. Elements in the same group have ________________ outer electronic structures and so form the same kind of chemical bonds. For example, the general outer structure of Group VII A elements is __________________. So all these elements have ______________ outer electrons which are represented by __________ dots in the electron dot notation. In this group, diatomic molecules such as F_2, Cl_2 and

Br_2 are all formed in the same way by ______________ a pair of electrons.

This kind of bond is called a ___________ bond. An electron paid bond can also be represented by a single _____________ drawn between the chemical symbols.

The O_2 molecule is formed by sharing ________ ___________ of electrons which

complete the ______________ for both atoms.

THE ATOMIC STRUCTURE OF NITROGEN IS AS FOLLOWS: $1s^2$, $2s^2$, $2p^3$. How many covalent bonds is nitrogen likely to form? Which electrons will be used?

Give the electron dot structure for N_2.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 22.

SECTION THREE:

1. Sketch πp_y^* M. O.

Sketch a σp_z M. O.

2. Give the M.O. structures of H_2^+ and He_2^+.

Is there a net bonding force for these molecules?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 38.

SECTION FOUR:

ON SEPARATE KRITTER SHEETS MAKE A MOLECULAR ORBITAL ENERGY DIAGRAM FOR: Be_2, B_2 and Ne_2. CALCULATE THE BOND ORDER FOR EACH MOLECULE. ATOMIC NUMBERS: Be = 4, B = 5, Ne = 10.

HAND IN TO YOUR INSTRUCTOR FOR CREDIT AT THE END OF THIS PACKET.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 48.

TM-7 CHEMICAL BONDING
PACKET #4 - FINAL EXERCISE - #862

WHEN YOU HAVE COMPLETED THIS SECTION, GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

1. TRUE-FALSE

________ In a covalent bond, the electrons are not free to move around as occurs in the metallic bond.

________ The noble gases are not as reactive as other non-metals because their attraction for electrons is not very great.

________ A molecular orbital is symmetrical about the internuclear axis.

________ The maximum occupance of a molecular orbital is the same as an atomic orbital - 2 spin-paired electrons.

________ Under normal conditions, bromine is the only liquid non-metal.

2. GIVE THE ELECTRON DOT STRUCTURES OF THE FOLLOWING MOLECULES: H_2, O_2, N_2 and Cl_2.

3. The M. O. energy diagram for the homonuclear diatomic molecules of period 2 is given in the programmed materials. Draw on a separate kritter sheet and give the orbital designations for each level.

4. Fill in the atomic structure for carbon (at. #6) on both sides of the M. O. diagram. Fill in the M.O. description of the C_2 molecule. Define bond order and calculate the bond order of C_2.

BE SURE TO HAND IN THE MOLECULAR ORBITAL DIAGRAMS OF QUESTIONS 3 & 4.

NAME: ______________________________

DATE: ______________________________

TM-7 CHEMICAL BONDING
PACKET #5 - #863 - BONDING - ATOMS OF DIFFERENT ELEMENTS: METALS AND NON-METALS: THE IONIC BOND - SELF QUIZZES.

SECTION ONE.

HERE ARE THE GENERALIZED ELECTRON STRUCTURES FOR THE A-GROUP ELEMENTS. GIVE THE CHARGE AND THE GENERALIZED ELECTRON STRUCTURES FOR THE CHARACTERISTIC IONS OF EACH GROUP.

GROUP	GENERALIZED ELECTRON STRUCTURES	CHARGE & STRUCTURE OF CHARACTERISTIC ION	
EX. I-A	core $(ns)^1$	+1	core
II-A	core $(ns)^2$	__	________
III-A	core $(ns)^2(np)^1$	__	________
IV-A	core $(ns)^2(np)^2$	__	________
V-A	core $(ns)^2(np)^3$	__	________
VI-A	core $(ns)^2(np)^4$	__	________
VII-A	core $(ns)^2(np)^5$	__	________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 19.

SECTION TWO:

DRAW THE ELECTRONIC STRUCTURES OF THE FOLLOWING METAL ATOMS AND THEIR CORRESPONDING IONS.

Ti

Ti^{+3}

Mn

Mn^{+2}

Cu

Cu^{+1}

Cu^{+2}

IONS WITH THE SAME ELECTRONIC STRUCTURES ARE SAID TO BE ISOELECTRONIC.

WHAT ION IS ISOELECTRONIC WITH Fe^{3+}?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART TAPE AND ADVANCE TO FRAME 22.

SECTION THREE:

1. Which has the greatest lattice energy, LiF or LiI?

2. Which has the greater lattice energy CsBr or BaO?

3. Which is more brittle, Ca or $CaCl_2$?

4. What are the electrolysis products from molten $CaCl_2$?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 29.

TM-7 CHEMICAL BONDING
PACKET #5 - #863 - BONDING - ATOMS OF DIFFERENT ELEMENTS: METALS
AND NON-METALS: THE IONIC BOND - FINAL EXERCISE.

---

1. ____ Which pair of elements will combine to form an ionically bonded compound? A. Mg and Na; B. K and F; C. F and Cl.

2. ____ The correct formula for a compound between magnesium and iodine is:

A. MgI; B. Mg_2I; C. MgI_2

3. ____ What are the ions in Al_2O_3? Cation ____________________
Anion ____________________

4. ____ Assuming their ionic radii are approximately equal, which of the following ionic solids has the highest lattice energy?
A. CaF_2; B. NaF; C. CaO

5. ____ Which of the following is most soluble in water?

A. C_2H_6; B. KCl; C. CCl_4

6. ____ Which of the following is not an electrolyte?

A. NaI; B. $MgCl_2$; C. CH_4

7. ____ Which of the following substances is most brittle?

A. Fe; B. CaI_2; C. I_2

8. ____ Which of the following substances will conduct electricity in the liquid state?

A. CS_2; B. $CsBr$; C. NO_2

WHEN YOU HAVE COMPLETED YOUR ANSWERS GIVE THE EXERCISE TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________________

DATE: ______________________________

TM-7 CHEMICAL BONDING
PACKET #6 - #864 - BONDING - ATOMS OF DIFFERENT ELEMENTS - NON-METALS:
COVALENT COMPOUNDS SELF QUIZZES

SECTION ONE:

GIVE THE ELECTRONIC DOT STRUCTURES FOR THE FOLLOWING MOLECULES:

HYDROGEN FLUORIDE (HF)

CHLOROFORM ($CHCl_3$)

HYDROGEN SULFIDE (H_2S)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 10.

SECTION TWO:

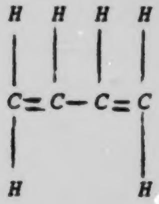
FILL IN THE ELECTRON DOT STRUCTURE FOR n-butane.

H H H H

H C C C C H

H H H H

THE STRUCTURE OF BUTADIENE IS GIVEN BELOW USING THE LINE NOTATION. CHANGE THIS TO THE ELECTRON DOT NOTATION.



$H_2C=CH-CH=CH_2$

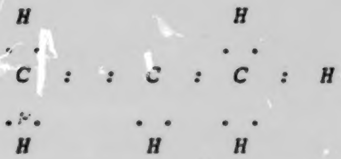
(BUTADIENE)

H H H H

C C C C

H H

THIS IS THE STRUCTURE OF PROPENE USING THE ELECTRON DOT NOTATION. CHANGE THIS TO THE LINE NOTATION.



(BUTADIENE)

H H

C C C H

H H H

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 15.

SECTION THREE:

From the hybridization patterns of Frame 28, predict the shapes of the following mokecules. Remember only outer electrons are used for chemical bonding, so elements in the same group form similar compounds. Consult a periodic table if necessary.

$BeCl_2$

SiH_4

BCl_3

NH_3

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 30.

SECTION FOUR:

1. Which hybridization pattern does carbon adopt in the following compounds?

METHANE	CH_4
ETHANE	$CH_3 \cdot CH_3$
ACETYLENE	HC CH
ETHYLENE	$CH_2 = CH_2$
DIAMOND	

ARE THE FOLLOWING STATMENTS TRUE OR FALSE?

1. ____ Nonpolar covalent molecules are insoluble in water.

2. ____ Solids composed of covalent molecules generally have high melting points.

3. ____ The attractive forces between water molecules and nonpolar covalent molecules are very weak.

4. ____ Covalent solids (like diamond) are soluble in covalent liquids such as CCl_4.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 39.

Tm-7 CHEMICAL BONDING
PACKET #6 - #864 - BONDING - ATOMS OF DIFFERENT ELEMENTS - NON-METALS:
COVALENT COMPOUNDS. FINAL EXERCISE.

---

1. Give the electron dot structures of the following molecules:

ETHYL ALCOHOL	CH_3CH_2OH
DIMETHYL ETHER	$CH_3 - O - CH_3$
NITROGEN TRIIODIDE	NI_3

2. Which hybridization schemes does carbon use in the following molecules? Sketch the electron orbital pattern for ethylene.

ETHANE	$H_3C - CH_3$
ETHYLENE	$H_2C = CH_2$
ACETYLENE	$HC \equiv CH$

3. Explain the meaning of the following terms. Illustrate your answer with examples.

ISOMERISM

CATENATION

-ORBITAL

WHEN YOU HAVE FINISHED HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________

DATE: ______________________

TM-7 CHEMICAL BONDING
PACKET #7 - #865 ELECTRONEGATIVITY SELF QUIZZES

SECTION ONE:

1. In a ________ bond, two atoms are held together by sharing a pair of electrons, with each atom donating one electron to the shared pair.

2. A covalent bond in which the electrons are not shared equally is a ________________ bond.

3. An electronegativity difference of _____________ represents a bond that is about 50% ionic and 50% covalent in character.

4. If the electronegativity difference between two elements is zero or very small, the bond has ___________% ionic character.

5. The bond between S and Cl in SCl_2 is mostly covalent.
True or False? __________

6. The electronegativity of Br is greater than the electronegativity of L.
True or False? ___________

7. The bond between Al and S in Al_2S_3 is covalent but quite polar.
True or False? _________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 11.

SECTION TWO:

1. In general, melting points of covalent molecules increase as the polarity of the molecules increase, all other factors equal.
True or False? ___________

2. In general, for non-polar molecules, the melting point increases in proportion to the increase in molecular size?
True of False? _______________

3. O_2,with a molecular weight of 32, will have a higher boiling ooint than HF which has a molecular weight of 20.
True or False? ______________

4. The solubility of ionic solids and polar covalent compounds in water is largely a result of the fact that water is a polar molecule.
True of False? ___________________

5. Under the same conditions, O_2 is more soluble in water than ammonia.
True or False?_______________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 21.

SECTION THREE:

1. A hydrogen bond is a weak electrical attraction of a covalently bonded hydrogen atom towards another atom.
True or False? ______________________

2. Hydrogen bonds are only formed by the most electronegative atoms.
True or False?

3. All the following compounds form hydrogen bonds.

HF, H_2O, NH_3 CH_4

True or False? ______________________

4. Hydrogen bond formation increases the boiling point of a compound above the value predicted just from molecular weight considerations. Hydrogen bond formation contributes to the anomalously high boiling point of water.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 29.

SECTION FOUR:

Write the structures of the following molecules using the line notation. Indicate which bonds are coordinate covalent bonds.

A) NH_4^+ (ammonium ion)

B) ClO_4^- (perchlorate ion)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 33.

PACKET #7 - END OF PACKET SELF QUIZ - #865

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1. Use the electronegativity table and % ionic character versus electronegativity difference graph to find the % ionic character of the following bonds.

   a. H - F

   b. H - I

   c. C - H

   d. O - H

   e. Li - I

MULTIPLE CHOICE:

2. _____ Which of the following would have the highest melting point?

   (a) CO_2 (b) Na_2O (c) SO_2

3. _____ Which of the following would be most soluble in water?

   (a) CH_4 (b) CCl_4 (c) HCl

4. _____ Which of the following is not an electrolyte?

   (a) HBr (b) CH_4 (c) KBr

5. _____ Which of the following will conduct electricity in the liquid state?

   (a) LiI (b) I_2 (c) HI

6. _____ Which of the following would have the highest melting point?

   (a) HF (b) HCl (c) HBr

7. _____ Which of the following would be most soluble in water?

   (a) HF (b) HCl (c) HBr

THE FOLLOWING SPECIES CONTAIN ONE OR MORE HYDROGEN BONDS. SUGGEST POSSIBLE STRUCTURES.

HF_2^-, $H_2F_3^-$, $SO_4^{-2} \cdot H_2O$

ASK INSTRUCTOR FOR KEY TO THIS EXERCISE, CORRECT AND HAND IN TO INSTRUCTOR FOR INSERTION INTO YOUR FOLDER.

MATCH THE PERSON TO THE ACCOMPLISHMENTS. YOU MAY USE YOUR 3" x 5" CARD FILE.

1. ____ Sir Isaac Newton
2. ____ Max Planck
3. ____ de Broglie
4. ____ Davisson & Gerner
5. ____ Thomson & Milliken
6. ____ Rutherford
7. ____ Balmer & Rydberg
8. ____ Niels Bohr
9. ____ Schrodinger
10. ____ Uhlenbeck & Goudsmit

A. light possesses both wave and particle properties; moving matter emits waves.

B. tested the deBroglie postulate and pooved both Bragg and deBroglie to be correct.

C. developed equations to explain the line spectro of hydrogen

D. resuscitated the corpuscular theory of light by starting the quantum theory.

E. $E_n = \frac{-2^2 \; me^2}{h^2 \; n^2}$; stability energy

F. corpuscular theory of light; the photoelectric effect; laws of motion; large portions of The Calculus

G. the total energy of the hydrogen atom , E, is the sum of its potential and kinetic energies.

H. most of the mass of an atom is packed in the dense nucleus

I. spectroscopic data explained if electrons possessed spins by direction (clockwise or counterclockwise)

J. determined that the electron was a small negatively charged particle.

MATCHING:

1. ____ 'c', the speed of light
2. ____ λ
3. ____ ν , frequency cs peaks
4. ____ Å, 1 angstrom
5. ____ h, proportionally constant fundamental to atomic size phenomena

A. 3×10^{10} cm/sec

B. Rydberg constant of the Balmer equation

C. Planck's constant

D. a probability measure of electron density

E. wavelengths of light or other electromagnetic wave

---

6. ____ ψ^2

7. _____ p-orbital

8. ____ f & g orbitals

9. ____ Z

10. ____ $R = 109,737\ cm^{-1}$

F. shapes complex and not important in determining chemical reaction rates or valences

G. 10^{-8} cm

H. nuclear charge

I. a nodal plane of zero electron density separates the two lobes

J. cycles/second

FILL IN THE MISSING TERMS:

1. ________________ ________________ ______________ states that each orbital can accommodate at most two electrons, and then only if their __________ are opposite or ______________________.

2. _______________ ____________ says that electrons prefer to occupy separate orbitals with their spins ____________________ provided that it is ______________ reasonable.

3. The energy necessary to draw out of a bond __________________ well is given the letter D and called _____________________ energy.

4. There are three major forms of molecular orbitals; MO's, the sigma bond given the symbol _______, the pi bond given the symbol __________, and the delta bond given the symbol ____________________.

5. Orbitals on the same atom which lie close to one another in _____________ have an unusual ability to combine to produce ___________________ bonds.

6. The hybrid molecular orbitals formed from 's' and 'p' orbitals are: sp, sp^2 and _______________________ hybrids.

7. Four dsp^2 hybrids of _______________ planarsymmetry may be constructed by mixing $d_{x^2-y^2}$, s. p_x and p_y orbitals.

8. Six ______________ d^2sp^3 hybrids are formed when the $d_{x^2-y^2}$, d_{z^2}, and s and the three p orbitals are mixed.

9. A peculiar weak bond connecting hydrogen to an electron ' greedy' atom on another molecule is especially important in biochemistry. The is the ____________________ bond.

10. In order to explain the highly complex nature of bonding of transition metals a new concept called _______________________________ theory is required.

WHEN FINISHED WITH THIS PART HAND IN TO INSTRUCTOR AND RECEIVE PART II OF THE TEST.

NAME: _________________________________

DATE: _________________________________

PART II

USING YOUR NOTES PRODUCE A 3 - D DRAWING OF EACH OF THE FOLLOWING:

BENZENE

FORMALDEHYDE

HYDROGEN FLUORIDE

BERYLLIUM II CHLORIDE

AMMONIA

NITROGEN GAS

WATER

CARBONATE

BORAZOLE

ORTHO-IODOPHENOL

TM - 8 ORGANIC CHEMISTRY

PURPOSE:

To assist the student in understanding organic chemistry.

MATERIALS:

1. Benfey, O. T. From Vital Force to Structural Formulas. AMERICAN CHEMICAL SOCIETY.
2. Geissman, T. A. Principles of Organic Chemistry, 3rd. Ed. W. H. Freeman & Co.
3. Leicester, H. M. The Historical Background of Chemistry. John Wiley & Sons, Inc,
4. MacKenzie. Unified Organic Chemistry. Harper & Bros. Pub.
5. Runquist, O. Organic Chemistry Reactions I and Nomenclature. Burgess Pub. Co.

OBJECTIVES: To enable the student to:

1. Draw structural formulae for organic chemicals.
2. Name organic chemicals given their structural formula.
3. Predict products of organic reactions.

DATE STARTED: ____________________

TM-8 ORGANIC CHEMISTRY INSTRUCTION & CHECK OFF SHEET

In this module you are introduced to the world of organic chemistry. If you have not completed chemistry modules TM-1 through TM-4 you may wish to utilize only packets 1 and 2. You may combine packets 1 and 2 with other packets to satisfy the requirement of six packets equal to one module, should nomenclature and reaction mechanisms of organic chemistry prove too difficult at this time.

PACKET #1 - THE DEVELOPMENT OF ORGANIC CHEMISTRY

READ LEICESTER: CHAPTERS 18 & 19 and complete the programmed review. Show 3" x 5" cards to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #2 - FROM VITAL FORCE TO STRUCTURAL FORMULAS.

Read all of this paperback before requesting the programmed review.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #3 -

Utilize any of the available Organic Chemistry texts and Runquist's Organic Chemistry Nomenclature programmed review.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #4 -

Utilize the Organic Chemistry Text and Runquist's Organic Chemistry Reactions: I.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

REQUEST END OF MODULE TEST.

DATE COMPLETED: ____________________

GRADE: ____________________________
INSTRUCTOR SIGNATURE: ______________

TM-8 ORGANIC CHEMISTRY
PACKET #1 - PROGRAMMED REVIEW

1. As knowledge of chemical facts increased in the 1700's it was recognized that products of living organisms were far less ______________ and far more ____________ than most mineral compounds. Bergman first separated substances into _______________ and inorganic. First to develop analytical procedures for organic compounds was __________. Gay-Lussac and Thenard improved organic analysis by introducing the use of ________ _______ agents. Greatest of the analysts was Justus ____________________.	
2. The nature of ____________ was explained by Chevreul. Friedrich Wohler produced the first 'acceptable' _______________ compound. The doctrine of "_________________" which had prevailed for many years was abandoned after 1860 when _____________ published Chimie Organique Fondee Sur la Synthese.	1. stable reactive organic Lavoisier oxidizing Liebig
3. Vitalism was replaced by the theory of ________ __________ as first discussed by Morveau, Lavoisier, Gay-Lussac, Berzelius, Dumas and Boullay. Liebig and Wohler extended the concept of the __________. In 1834 Dumas inadvertantly challenged the radical theory when he introduced the concept of ___________ which he called metalepsy. Between 1835 and 1840, August _______________ stressed the idea that _____________ were a 'fundamental radical' from which various '_______________ radicals could be obtained by ______________________________.	2. fats organic vitalism Berthelot
4. Laurent, despite virtual exile, developed 'nucleus' theory and his ideas on classification were used by _________________ and _______________ in their influential giant chemistry. Gerhardt carried on the work of _________________________.	3. radicals radical substitution Laurent hydrocarbons derived substitution
	4. Gmelin Beilstein Laurent

5. Strong evidence for the existence of free-________ came from Bunsen's work on ________. Herman Kolbe electrolyzed potassium acetate and obtained ________.	
6. Wurtz discovered in 1849 the primary ________. Hofmann explained the relationship between amines and ________. Williamson was first to artificially prepare ________. The first secondary alcohol was prepared by ________ in 1862, the first tertiary alcohol by ________ in 1864.	5. radicals cacodyl ethane
7. The term 'valence' was finally introduced by ________ in 1868. This directred the attention of chemists to the problem of ________.	6. amines ammonia ethers Friedel Butlerov
8. The nature of organic structural chemistry was simultaneously explained by the two chemists ________ and ________.	7. Wichelhaus affinity
9. When Markovnikov studied acetyl chloride and ethyl chloride he produced the first study of the effect of ________ structure on organic ________. van't Hoff and Lebel considered carbon to geometrically be ________. Stereochemistry was introduced by Pasteur and ________. Emil Fischer worked on ________ sugars. Strain theory was introduced by Adolf ________; steric hindrance was explained by Victor ________. That Stereochemistry was important in non-carbon chemistry was shown by Pope and ________.	8. Kekule Couper
	9. electron reactions tetrahedral Wislicenus isomeric Baeyer Meyer Werner

10. Unfortunately the giants of ____________ chemistry did not bother with ______________ chemistry or mathematics. The two fields developed ___________________ and well separated. They were brought back together in the 1900's.

10. organic
physical
simultaneously

TM-8 ORGANIC CHEMISTRY
PACKET #2 - FROM VITAL FORCE TO STRUCTURAL FORMULAS

This little book, hopefully, will provide an insight into the long and tortuous history behind the development of what scientists now call ORGANIC CHEMISTRY.

Please read it from cover-to-cover remembering to keep tabs on the people involved in this travelogue through time, the new scientific terms and the new information you acquire about the elements, especially carbon.

When you have finished, complete this programmed review, but do not spoil the flow of thought by plodding through looking for the answers first! The author is a fine writer as well as a chemist.

1. Given the set of valence rules a person should be able to write endless structural formulas which should ________________ to the substances in nature.	
2. It (is, is not) true that endless such formulas can be written.	1. correspond
3. The dimensions missing in the early theories about organic chemistry forgot ____________ and ______________________.	2. IS NOT!
4. To describe organisms just as to describe physics, not only atoms must be dealt with, but the dimensions of __________________ and ______________________.	3. time space
5. Just as living creatures grow and metamorphose, so ___________________ molecules change with __________. Just as creatures have volume and occupy different amounts of space over time so too do ______________ molecules occupy _____________________.	4. time space
6. It was ____________ who commented "that physics deals with small ________________ and biology deals with larger ones".	5. organic time organic space
	6. Alfred N. Whitehead organisms

7. Another scientist-philosopher suggested to Benfey that he develop the idea of tracing down a ____________ set of _______________ to their _______________. This scientist was _______________.	
8. Benfey states that "the _____________ of scientific facts are the ______________ heroes of the history of science". "The richer the ______________ material; the more easily and readily does it allow itself to be fitted into a few basic forms".	7. simple concepts origin Leonard K. Nash
9. It was difficult for early chemists like Lavoisier and Scheele to understand how such a vast array of ________________ materials could be produced from only three or four _____________. These elements were: ____________, ______________, _______________, and ______________.	8. accumulators unsung empirical
10. For quantitative determination of carbon and hydrogen excess oxygen if supplied using $KClO_3$ or ________________, Carbon-dioxide is absorbed in _______________ just as Justus Liebig did in 1831. Water produced is absorbed in anhydrous ____________. Now if the hydrogen is all in water and its weight is known and if the carbon is all in CO_2 then per cent composition of ________ and ___________ can be _________________.	9. differing elements C O H N
11. When chemists attempted to apply _______________ conceptual scheme of dualism, so eminently successful with INORGANIC chemistry to organic chemistry they were _____________________. The enigma of organic chemistry produced a principle called a '______________________________'.	10. CuO KOH $CaCl_2$ C H calculated
	11. Berzelius's baffled vital force

---

12. Although urea was the first chemical historically recognized __________________ as produced by __________, another organic compound ____________________ acid had been produced from inorganic chemicals, in 1824, but this was considered a borderline organic chemical.

---

13. Analytical data stating the ____________ percentages of the elements present in an organic compound are not obtained by simple ________________. observation. They are only as accurate as the _____________ used and the assumed % composition of _______________ and ____________________ _____________. With careful analysis it was discovered that substances with different chemical ___________ had the empirical ________________. These substances Berzelius termed ________________________.

12. organic
man
oxalic

---

14. After Wohler defended his 'strange' findings against attack by Liebig he worked on _________________. It had the same % composition as Faraday's discovery ____________________. Berzelius called these ____________________.

13. weight
direct
method
water
carbon dioxide
properties
formula
isomers

---

15. In 1832 in Jahresbericht, Berzelius arrived at a mixture concept of _________________. He used olefiant gas, which we call ______________ with the formula ______________. He then recognized that C_4H_8 was an _____________ and was __________________.

14. butylene
ethylene
polymers

---

15. isomerism
Ch_2

ethyle

C_2H_4
isomer
butylene

CM-8 ORGANIC CHEMISTRY
PACKET #2 (cont.)

16. Wohler also recognized that crystals of metals and anions like SO_4^{2-} or ClO_4^{1-} developed __________ series. $KClO_4$ crystallized like ________________. K_2SO_4 like ________________ or ________________	
17. Over a ______________ distinct compounds are now known to consist of only _____________, _______________, _________________ and ________________.	16. isomorphous $KMnO_4$ K_2SeO_4 K_2CrO_4
18. In 1815 Gay-Lussac produced a whole series of compounds which contain the ___________ radical. Give formulae for: prussic acid ________________, mercury II cyanide ____________________, cyanogen ____________________, and chlorcyanogen _____________. In those days the French called nitrogen ______________. What do Azotobacter do? ______________________________	17. million C O H N
19. Just as in inorganic chemistry the basic key to learning is the ___________________; in organic chemistry a basic key to understanding is the ___________________.	18. cyano- HCN $Mg(CN)_2$ $(CN)_2$ ClCN azote
	19. element radical

20. Wohler worked for forty-four years with __________ who had often been his critic. One of their most important accomplishments was in describing the production of oil of __________ __________ which we know as __________________. This was a clear example of the existence of a stable ____________ called benzoyl.	
21. In rapid succession 'radicals' were discovered in the 1800's, Kane discovered the ____________ radical - C_2H_5. Dumas discovered the ____________ radical $(CH_3)_2$.	*20. Liebig bitter almonds benzaldehyde radical*
22. Although Wohler, Liebig, Gay-Lussac and Faraday had produced substitution in compounds of ____________ for _______________ they did not elaborate a theory of _______________ as did __________________.	*21. ethyl methyl cacodyl*
23. The credit for pushing forward a halogenation theory has to go to Dumas's student ______________ who held out for halogen replacement of ____________ on a basic hydrocarbon skeleton he called a fundamental _________________. It is Laurent who in his doctoral thesis proposed a _____________ model for organic compounds. Dumas finally accepted Laurent's ideas in his theory of ______________________.	*22. chlorine hydrogen substitution Dumas*
24. Both Laurent and _______________ went on to accept the Avogadro _________________ and changed the formulas of chlorine and oxygen to ______________ and ______________. They also changed atomic ____________ to what they are today.	*23. Laurent hydrogen radical geometrical (3-D) types*
25. A complete break with Berzelius and Liebig came with Laurent's ____________ _____________ formulae. He suggested very simple compounds as fundamental ___________ in which hydrogen was replaceable by either ___________________ or _____________________.	*24. Gerhardt hypothesis Cl_2 O_2 weights*
	25. water type types elements radicals

26. Williamson utilized ______________ theory to produce ____________________ from ethyl ____________. Later he produced methyl ethyl ether from ___________ and CH_3I and from CH_3OK and ______________________. Water types were now extended to acids and __________ by ___________________.	
27. Anhydrides of acetic and other acids were formed by ______________________ in 1852. Wurtz was first to recognize that methyl- and ethylamines were much like _______________. He recognized that ammonia, amines and the alkaloids belonged to another 'type'. He had discovered the nature of organic _____________	26. substitution ether alcohol C_2H_5OK C_2H_5I esters Williamson
28. When radicals were 'discovered' and the multiple types allowed them the modern idea of ______________ germinated. In 1857 Kekule advanced his combination of types and introduced mono-, _________ -, and _______________- atomic radicals.	27. Gerhardt ammonia bases
29. The idea of free-radicals was suggested by __________________, and attempted by ________________. Instead of 'ethyl' gas he obtained the gas ___________. Conclusive evidence for a free radical was not obtained until 1900 by Moses and _______________. From Frankland's researches developed the concept of ___________.	28. valence di tri
30. Gerhardt had proposed four 'inorganic types'; HH, HCl, H_2O, and NH_3. Odling proposed the fifth type which he called the ______________________ type. It was _______________ who first recognized that carbon was tetrabasic, or tetratomic and wrote methane as _________ and carbon tetrachloride as ________________________.	29. Bunsen Frankland butane Gomberg valence
	30. methane Kekule CH_4 CCl_4

31. Kekule classed reactions as (a) ______________, (b) __________ ____________ and (c) ____________ ________________.	
32. Kekule developed the first method of symbolically representing molecules which show possible reaction sites. He used as illustration benzene ____________ acid and displayed three formulae. "In general the most ____________ formula will express the ____________ of a body most completely.	*31. combination direct addition mutual decomposition (double exchange)*
33. Next Kekule proves that carbon has a major valence of ______. As he puts it, "This leads to the news that carbon is ____________". He goes on to devise the formula expressing the alkane or ________ series. In this formula C_nH_{2n+2}, n equals the number of ______________ in the chain.	*32. sulfonic rational nature*
34. Only a few weeks after Kekule's paper Dumas presented a paper on chemical theory to the French Academy of Science written by ____________. He too determined that the valence of carbon is __________. Lines and __________ were used to show atomic __________. Couper, in his formula for cyanuric acid was the first to show an organic __________. Couper's background in ____________ made possible a melding of chemical and philosophical thought.	*33. four tetratomic paraffin carbons*
35. With the publication of the papers of Couper and __________ the essential principles for the development of ____________ formulas were established. Even so well known chemists like the Russian, __________ and the German __________ criticized Couper's work. Couper's enemy __________ used Couper's formulae in his lectures and books. The first person to designate valence by a separate line was another Scotsman, ________________.	*34. Couper four dots linkages ring linguistics*
	35. Kekule structural Butlerov Kolbe Wurtz Brown

36. In 1858 Butlerov at a conference in Speyer, Germany, emphasized the use of ________________ formulas. He admitted the ideas were from ___________. Double and triple bonds first appeared in papers by Loschmidt, Brown and ____________. It was Erlenmeyer who coined the phrase '____________'. The benzene ring was introduced by ____________ in 1861. Isomerism of phthalic and terephthalic acids were explained by ______________. By 1874 Koerner had developed the _____________ concept further and was able to show substitution positions on the basic _____________ ring. These were called ______________, ______________, and _______________ positions.	
37. A number of cases became known where a substance was most suitably represented by one formula at one time and another formula at another! That this actually occurred in nature was proven in 1911. This concept is termed ____________________________. Pasteur developed the concept of ________________. Resonance theory was developed by several chemists in recent times. Developers include: ________________, ________________, ________________, and __________.	36. structural Couper Erlenmeyer unsaturated Loschmidt Kekule isomerism benzene ortho- meta- para-
	37. tautomerism stereoisomerism Arndt Ingold Robinson Pauling

TM-8 ORGANIC CHEMISTRY
END OF MODULE TEST

MATCHING:

1. _____ KEKULE & COUPER	A. Limiting Factor Law of plant nutrition....artificial fertilizer established early chemistry teaching laboratory..... Condenser still bears his name.
2. _____ LAVOISIER	B. it is possible from chemical evidence to represent the patterns of linkages among atoms in a molecule.
3. _____ SCHEELE	C. prepared cyanamide.....the reaction of aldehydes with bases is named after him.
4. _____ BERZELIUS	D. discovered selenium, silicon, thorium, ...determined atomic weights, started symbols for elements.
5. _____ LIEBIG	E. isolated aluminum and beryllium; made calcium carbide and silane....analogies between C and Si.
6. _____ DUMAS	F. isolated lactic acid from sour milk and from vegetables......discovered or identified; chlorine, oxygen, and hydrogen fluoride.
7. _____ AVOGADRO	G. physicist, lawyer, mathematics professor first to distinguish between atoms and molecules
8. _____ CANNIZZARO	H. Laurent's teacher.....method of determining atomic weights....synthesized nitriles, organic nitrates trichloroacetic acid.
9. _____ WOHLER	I. "All atomic weights are integral multiples of the atomic weight of hydrogen-". Stomach acid is HCl.
10. _____ PROUT	J. chemist, economist, agriculturalist, Sec.-Treasurer of the commission that sets up the Metric System. Explained combustion and respiration.....key figure in modern nomenclature.

GIVE STRUCTURAL FORMULAE FOR:

A. PROPANE

B. Z-BUTENE

C. I-PROPYNE

D. METHYL VINYL CARBINOL

E. VINYL CHLORIDE

F. n-butyric acid (butanoic acid)

G. ETHYL AMINE

H. 1, 5-HEXADIENE

I. 1, 3-PENTADIYNE

J. PHTHALIC ACID

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY

PURPOSE:

To assist the student in developing an understanding of the theory behind and the mathematical manipulations with that portion of aqueous chemistry involved in acid-base, redox and electrochemical reactions.

MATERIALS:

1. Kass, G. A. Programmed Texts: Vol. V. Acid-Base Chemistry and Vol. VI. Redox and Electrochemistry. W. A. Benjamin & Co.

2. Communication Skills Corporation Slide Tape Presentations.

#881 - Chemical Equilibria, Molecular and Ionic, Problems Involving K_{eq} & K

#882 - Common Ion Effect Principle, Ion Product Constant for Water, and Introduction to pH.

#883 - pH, pOH, and Buffers

#884 - Hydrolysis of Salts

#885 - Polyprotic Acids and Solubility

#886 - Titration Curves and Indicators

Communication Skills Corp., P. O. Box 684, Fairfield,
Conn., 06430

3. Markson Science Inc. Free brochure of pH, Specific Ion & Conductivity. Markson Science, Inc., 43 Maple Avenue, Dept. 203, New York, N.Y. 10956

4. The Chemistry Problem Solver: C. M. Fugiel, Ed. Research & Education Assn., 342 Madison Avenue, New York, N.Y. 10017

5. Reference Chemistry Texts (Instructor's Choice)

OBJECTIVES: To enable the student to:

1. Compare strengths of acids

2. Determine acid-base pairs

3. Calculate pH and pOH

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY (cont)

4. Predict acid-base reactions
5. Determine the common ion effect
6. Prepare buffered solutions
7. Balance redox-equations
8. Measure half-potentials
9. Utilize the Nernst equations
10. Use titration equipment with indicators

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY

DATE STARTED: ____________________

INSTRUCTION AND CHECK OFF SHEET

INTRODUCTION: This specialized unit concerns the concepts which grew from the COMMON-ION, OXIDATION-REDUCTION and ELECTROCHEMISTRY PRINCIPLES. It is a challenging module, but a very rewarding area for the student who expects to understand pH, pOH, solubility, titration, electrochemistry and a host of acid-base related problems which the environmental scientist must comprehend.

PACKET #1 - ACID-BASE CHEMISTRY
Utilize Kass's Acid-Base Chemistry programmed text. When you feel that you sufficiently understand the materials ask for the end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2 - #881 CHEMICAL EQUILIBRIA: MOLECULAR AND IONIC, PROBLEMS INVOLVING K_{eq} AND K.

Review this tape and utilize self-quizzes. Request end of packet quiz.

- #882 COMMON ION EFFECT PRINCIPLE, ION PRODUCT CONSTANT FOR WATER, AND INTRODUCTION TO pH.

Review this tape and utilize self-quizzes. Request end of packet quiz for this unit.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3 - #883 pH, pOH, AND BUFFERS
Utilize this tape and the self-quizzes. Request end of packet quiz.
Read Markson Science, Inc., Laboratory pH, Specific Ion and Conductivity.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4 - #884 HYDROLYSIS OF SALTS
Review this tape and the self-quizzes. Request end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY (cont.)

DATE STARTED: ______________________

INSTRUCTION AND CHECK OFF SHEET

PACKET #5 - #885 POLYPROTIC ACIDS AND SOLUBILITY
Review this tape and the self-quizzes. Request end of packet quiz.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #6 - #886 TITRATION CURVES AND INDICATORS
Review this tape and the self-quizzes. Request end of packet quiz.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET # 7 - REDOX AND ELECTROCHEMISTRY
Utilize Kass's programmed text - Vol. VI. Take the end of packet quiz after mastering this text and reviewing Chapter 7 in Leicester.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

REQUEST END OF MODULE TEST

TEST GRADE: ______________
DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #1 END OF PACKET QUIZ

---

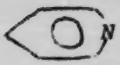
1. In the reaction CO_3^{-2} $H_2O = HCO_3^- + OH^-$, the two acids are:

A. HCO_3^- and OH^{-3} B. H_2O and CHO_3^- C. CO_3

D. CO_3^{-2} and OH^-

2. Which of the following is not likely to behave as a base?

A. NH_3 B. Na^+ C.



D. PO_4^{-3}

3. In the reaction: $HSO_4^- + HPO_4^{-2} = H_2PO_4^- + SO_4^{-2}$, the proton donor

in the forward (left to right) reaction is:

4. Which of these four K_A values would represent the weakest acid?

A. 2.1×10^{-2} B. 4.0×10^{-4} C. 6.7×10^{-12} D. $3,0 \times 10^{-1}$

5. In the reaction $HSO_4^- + NH_3 = NH_4^+ + SO_4^{-2}$, which set represents an acid-base conjugate pair?

A. HSO_4^- and SO_4^{-2} B. HSO_4^- and NH_3 3. NH_4^+ and HSO_4^-

D. NH_3 and SO_4^{-2}

6. In the reaction $HC_2O_4 + PO_4^{-3} = HPO_4^{-2} + C_2O_4^{-2}$, the two Bronsted bases are:

A. $HC_2O_4^-$ and PO_4^{-3} B. HPO_4^{-2} and $C_2O_4^{-2}$ C. $HC_2O_4^-$ and HPO_4^{-2}

D. PO_4^{-3} and $C_2O_4^{-2}$

7. The conjugate acid of HPO_4^{-2} is:

A. PO_4^{-3} B. $H_2PO_4^-$ C. H_3PO_4 D. $H_4PO_4^+$

8. The conjugate acid of NH_2^- is:

A. NH_2OH B. NH_4^+ C. NH^- D. NH_3

9. Which of the following is most likely to be amphiprotic?

A. HCl B. $H_2PO_4^-$ C. CO_3^{-2} D. CCl_3COOH

10. According to the Bronsted Lowry theory, why is the PO_4^{-3} ion not amphiprotic?

A. It has a negative charge; B. it contains too many oxygen atoms;
C. the mass of the ion is too large; D. there are no hydrogen atoms in the formula.

---

11. Which statement is true for the equilibrium system: $CH_3COOH + H_2O = H_3O^+ = CH_3COO^-$?

A. There are more ions than molecules. B. The pH is likely to less than one. C. There are more molecules than ions. D. The reaction goes to completion.

12. If a solution of $NaHSO_4$ reacts with NH_3, which is the acid?

A. Na^+; B. NH_3; C. SO_4^{-2}; D. HSO_4^-

13. As the ionization or acid constant of an acid increases, its proton-donating ability: A. increases; B. decreases; C. remains the same.

14. Which of these reactions least favors the products at equilibrium?

A. $HCO_3^- + H_2O = H_3O^+ + CO_3^{-2}$; B. $HSO_4^- + CO_3^{-2} = HCO3^- + SO_4^{-2}$;

C. $HCl + H_2O = H_3O^+ + Cl^-$; D. $HC_2O_4^- + NH_2^- = NH_3 + C_2O_4^{-2}$

15. If K_1 for the triprotic acid H_3B is $1,3 \times 10^{-2}$, which of these is the most likely value for K_2?

A. 1.3×10^2; B. $1.7 \times ;0^{-1}$; C. 2.4×10^{-2}; D. 2.4×10^{-5}

16. Which of the following reactions would be governed by the K_3 of H_3PO_4?

A. $H_3PO_4 = H^+ + H_2PO_4^-$ B. $H_2PO_4^- + H^+ = H_3PO_4$

C. $H_2PO_4 = H^+ + HPO_4^{-2}$; D. $HPO_4^{-2} = H^+ + PO_4^{-3}$

17. The symbol "$H^+_{(aq)}$" could represent any of the following EXCEPT:

A. H_3O^+; B. OH^-; C. $H_5O_2^+$; D. $H_9O_4^+$.

18. If the $[H^+] = 1 \times 10^{-4}$ M, then the $[OH^-]$ equals:

A. 1×10^4 M; B. 1×10^{-4} M; C. 1×10^{-10} M; D. 1×10^{-14} M

19. Which of the following expressions represents K_w?

A. $[H^+]\,[OH^-]$ B. $\dfrac{[H^+]\,[OH^-]}{[H_2O]}$ C. $\dfrac{[H^+]}{[OH^-]}$ D. $\dfrac{[H_2O]}{[H^+]\,[OH^-]}$

---

20. If the $[H^+]$ of a certain solution is 2.8×10^{-5} M, the pH is:

A. 2.8; B. 4.6; C. 5.3; D. 11.2

21. If the $[H^+]$ of a certain solution is 1×10^{-4}, the pH is:

A. -4; B. 4; C. 10; D. 14

22. If the pOH of a solution is 6, the pH is:

A. 6; B. 8; C. 10; D. 14

23. The range of the acid-base indicator chlor-phenol red is 4.8 (yellow) to 6.8 (red). If a solution is red to this indicator, which statement is true?

A. The pH is 6.8; B. The pH is definitely acidic; C. The pH is between 1.0 and 6.8; D. The pH is between 6.8 and 14.

24. An indicator has $K_A = 1 \times 10^{-6}$. Its acid form is yellow and its basic form blue. In a solution of pH 7, this indicator will be: A. yellow; B. blue; C. green; D. can't tell, not enough information.

25. Which of the following statements would be true when Na_3PO_4 is dissolved in water?
A. The PO_4^{-3} ion acts as a base toward water. B, The Na^+ ion acts as a base toward water. C. The PO_4^{-3} acts as an acid toward water. D. The Na^+ ion acts as an acid toward water.

26. Which of the following might be a reasonable hydrogen ion concentration for a C.2M solution of $AlCl_3$?

A. 10^{-1}; B. 10^{-3}; C. 10^{-7}; D. 10^{-10}

27. Which of these when dissolved in water will yield a solution that is closest to being neutral?

A. KBr; B. K_3PO_4; C. K_2S; D. KOH

28. The number of gram equivalents in 0.5 mole of H_2SO_4 is:

A. 0.25; B. 0.50; C. 0.75; D. 1.00

29. What is the normality of 0.3M H_3PO_4?

0.1N; B. 0.3N; C. 0.6N; D. 0.9N

---

30. What is the molarity of 0.2N Na_2CO_3 solution?

A. 0.05M; B. 0.10M; C. 0.20M; D. 0.40M

31. How many milliliters of 0.1M NaOH are required to neutralize 100 ml of 0.1M H_2SO_4?

A. 25; B. 50; C. 100; D. 200

32. It required 22.0 ml of 0.10N HCl to neutralize completely 31.0 ml of Na_2CO_3. What is the normality of the sodium carbonate solution?

A. 0.04N; B. 0.07N; C. 0.10N; D. 0.53N

33. The pH of 0.01M acetic acid is most likely to be:

A. 1.0: B. 2.0; C. 3.4; D. 8.2

34. The pH of a 1.0M HCN solution is approximately 4.6. If NaCN is now added to this solution, the pH is most likely to be:

A. 2.3; B. 4.6;; C. 5.4; D. 9,2

35. Which of the following would be least likely to change the pH of an acetic acid solution?

A. CH_3COONa; B. NaCl; C. HCl; D. NaOH

36. Suppose that a small amount of 1M HCl is added to a carbonate-bicarbonate buffer system. Which statement is the most reasonable?

A. The pH increases sharply. B. The additional H^+ ions react with CO_{-3}^{-2}.
C. The pH decreases sharply; D. The addition H^+ ions react with HCO_3.

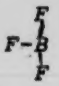
37. $Zn(OH)_2$ is amphoteric. This means that:
A. It is insoluble under any circumstances. B. It is soluble in acid only; C. It is soluble in base only, D. It is soluble in either acid or base.

38. Non-metallic oxides are most likely to be:

A. acids; B. bases; C. none of these

39. A Lewis acid: A. must contain H atoms; B. is always a proton donor; C. is an electron-pair donor; D. is an electron-pair acceptor.

40. Under the Lewis theory of acids and bases, boron trifluoride:



BF_3

is: A. an acid; B. a base; C. neither an acid nor a base; D. an amphoteric compound.

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #2 - SELF QUIZZES

NAME: ______________________________

DATE: ______________________________

SECTION ONE:

1. *List four factors which affect the rate of a chemical reaction.*

a.　　　　　　　　b.

c.　　　　　　　　d.

2. *The Law of Mass Action states that the ____________________ of a chemical reaction is ______________ to the _______________ of the ___________ of the reacting substances, each raised to the power corresponding to the ____________ of that species in the balanced chemical equation.*

3. *When two opposing reactions are occuring at the same rate, the reaction system is in ________________________.*

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION TWO:

1. *Write expressions for the equilibrium constants of each of the following reactions.*

A. $2SO_2 + O_2 \rightleftharpoons 2SO_3$

B. $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

C. $N_2O_4 \rightleftharpoons 2NO_2$

2. *Analysis of an equilibrium mixture of:* $CO_2 + H_2 \rightleftharpoons CO + H_2O$ *at* $700^{o}K$ *gave the following concentrations:*

$[CO]$ = 7.0 mol/l., $[H_2O]$ = 0.21 mol/l., $[CO_2]$ = 5.0 mol/l, and

$[H_2]$ = 3.0 mol/l. *CALCULATE* K_{eq} *for this equilibrium.*

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 23.

SECTION THREE:

A weak acid HA ionizes as follows: $HA = + H_2O \quad H_3O^+ + A^-$

A $0.2\underline{M}$ solution of HA is 1% ionized at 25°C. Calculate K_a for this acid at 25°C.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 29.

SECTION FOUR:

A weak acid HA ionizes as follows: $HA + H_2O \qquad H_3O- + A^-$

The acid concentration is $1.0 \times 10^{-2}\underline{M}$ and $K_a = 10^{-3}$. Calculate the hydronium ion concentration H_3O^+. The answer to this problem requires the solution of a quadratic equation. The formula solution of the general quadratic

$$ax^2 + bx + c + O \text{ are:}$$

$$\frac{-b \pm b^2 - 4ac}{2a}$$

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 33.

SECTION FIVE:

USE THE APPROXIMATE FORMULA JUST DISCUSSED TO THE CALCULATIONS IN THIS SECTION.

1. Calculate the H_3O^+ concentration in the solutions of the following weak acids.
   - A. $1.0\underline{M}$ formic acid, $K_a = 1.8 \times 10^{-4}$
   - B. $1.0\underline{M}$ acetic acid, $K_a = 1.8 \times 10^{-5}$
2. Calculate the OH^- concentration in the solutions of the following weak bases.
   - A. $0.1\underline{M}$ NH_3, $K_b = 1.8 \times 10^{-5}$ B. $0.01\underline{M}$ pyridina, $K_b = 6.5 \times 10^{-6}$

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 39.

TM-9 ACID-BASE, REDOX AND ELECTROCHAMISTRY
END OF PACKET QUIZ

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1. Write the equilibrium constant for each of the following reactions:

A. 2NOCl $\qquad$ $2NO + Cl_2$

B. COCl $\qquad$ $CO + Cl_2$

C. $H_2 + I_2$ $\qquad$ 2HI

2. A 0.5M solution of monoprotic weak acid HA is 2% ionized. Calculate K_a for the acid.

3. Calculate the hydronium ion concentration H_3O^+ in a 0.05M solution of hydrofluoric acid HF. K_a for HF is 4×10^{-4}. (Hint: You must solve the quadratic equation in this problem.)

4. Calculate the ammonium ion (NH_4^+) concentration in 0.1M NH_3 solution K_b for NH_3 $= 1.8 \times 10^{-5}$. (Use the approximate formula)

5. Calculate the hydronium ion concentration H_3O^+ in a 5.0M solution of a monoprotic weak acid HF

$$K_a = 5.0 \times 10^{-5}$$

NAME: ______________________________
DATE: ______________________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #2 - #882 - COMMON ION EFFECT PRINCIPLE, ION PRODUCT CONSTANT
FOR WATER, AND INTRODUCTION TO pH - SELF QUIZZES

SECTION ONE:

1. Calculate the $\left[H_3{}^{+}O\right]$ in a $0.01\underline{M}$ solution of HF. Assume the K_a of HF $= 4 \times 10^{-4}$.

2. Calculate the $\left[H_3{}^{+}O\right]$ in a $0.01\underline{M}$ solution of HF to which NaF has been added until the $\left[F^{-}\right] = 1\underline{M}$.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 11.

SECTION TWO:

In the following acid-base equilbria, label each species as an acid (A) or a base (B) according to the Bronsted theory.

$$CH_3CO_2H + H_2O \rightleftharpoons H_3{}^{+}O + CH_3CO_2{}^{-}$$

$$NH_3 + H_2O \rightleftharpoons NH_4{}^{+} + OH^{-}$$

$$H_2O + H_2O \rightleftharpoons H_3{}^{+}O + OH^{-}$$

2. List the conjugate bases of the following acids.

$HSO_4{}^{-}$ ______________________

HCN ______________________

HCl ______________________

3. List the conjugate acids of the following bases.

$HSO_4{}^{-}$ ______________________

OH^{-} ______________________

H_2O ______________________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 24.

SECTION THREE:

$$\boxed{K_w = 1 \times 10^{-14} = [H_3^+O][OH^-] \qquad (25^\circ C)}$$

1. What is the $[OH^-]$ in the following solutions (at 25°C):

   A. 0.01$\underline{M}$ sodium hydroxide (NAOH)

   B. 0.01$\underline{M}$ hydrochloric acid (CHl)

   C. Pure water

2. What is the $[H_3^+O]$ in the following solutions (at 25°C):

   A. 1.0$\underline{M}$ nitric acid (HNO_3)

   B. 1.0$\underline{M}$ sodium hydroxide

   C. Pure water

SECTION FOUR:

$$\boxed{pH = -\log\ H_3^+O}$$

Calculate the pH of the following solutions of strong acids and bases. You will need to use the log tables included in this workbook.

A. 1.0$\underline{M}$ hydrochloric acid (HCl)

B. 0.05$\underline{M}$ perchloric acid ($HClO_4$)

C. 1.0$\underline{M}$ sodium hydroxide (NaOH)

D. 0.04$\underline{M}$ potassium hydroxide (KOH)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION FIVE:

1. Calculate the pH of a 0.02$\underline{M}$ sckution of a weak acid.
   ($K_a = 5 \times 10^{-3}$)

2. Calculate the pH of a 0.02$\underline{M}$ solution of a weak base.

   ($K_b = 5 \times 10^{-3}$)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 44.

TM-9 ACID BASE, REDOX AND ELECTROCHEMISTRY
PACKET #2 - #882 - COMMON ION EFFECT PRINCIPLE, ION PRODUCT CONSTANT FOR WATER AND INTRODUCTION TO pH.

FINAL EXERCISE:

1. Calculate the $[H_3^+O]$ of a 2.0$\underline{M}$ solution of acetic acid ($K_a = 1.8 \times 10^{-5}$) to which soldium acetate has been added to give an acetate ion concentration of 0.36$\underline{M}$.

$$CH_3CO_2H + H_2O \qquad H_3^+O + CH_3CO_2^-$$

What is the pH of this solution? Label each species in the above equation acid or base according to the Bronsted theory.

2. Calculate the $[OH^-]$ and the pH of 1$\underline{M}$ methylamine solution.

$$(K_b = 4 \times 10^{-4},\ K_w = 1 \times 10^{-14})$$

$$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$$

Label each species in the above equation acid or base according to the Bronsted theory.

WHEN YOU HAVE COMPLETED THE EXERCISE, GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

STUDENT'S NAME: ______________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #3 - #083 - pH, p OH and BUFFERS - SELF QUIZZES

SECTION ONE:

Calculate the pH and pOH of the following solutions:
($K_w = 1 \times 10^{-14}$ at 25°C.)

1. Pure water

2. 0.1M NaOH

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 8.

SECTION TWO:

Formulas:

$$pK_a = -\log K_a$$

$$pH = \frac{1}{2}k_a - \frac{1}{2}\log c \quad \text{(weak acid)}$$

$$pH = 14 - \frac{1}{2}pK_b + \frac{1}{2}\log c \quad \text{(weak base)}$$

1. K_a for hydrofluoric acid (HF) is 7.2×10^{-4}

   Claculate pK_a ($\log 7.2 = 0.8573$).

2. A weak acid has a pK_a of 5.4. Calculate the pH of a 1,0M solution of this acid.

3. A weak base has a pK_b of 4.8. Calculate the pH of a 0.01M solution of this base.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 20.

SECTION THREE:

1. Which of the following solutions are good buffers?

   A. 0.1M sodium acetate + 0.1M acetic acid

   B. 0.001M sodium acetate + 1.0M acetic acid

   C. Pure water

   D. 1.0M sodium hydroxide

   E. 0.001M hydrochloric acid

   F. 1.0M ammonia + 2.0M ammonium chloride

2. Use Henderson's equation to calculate the pH of a so;ution 0.1M in hydrochloric acid (HF) and 1.0M in potassium fluoride (KF) (pK_a for HF = 3.2)

SECTION THREE (cont.)

Henderson's Equation

$$pH = pK_a + \log \frac{(salt)}{(acid)}$$

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART TAPE AND ADVANCE TO FRAME 36.

FINAL REVIEW EXERCISE:

Calculate the pH of the following solutions. You'll need the information listed below.

A. 0.005*M* sodium hydroxide

B. 5.0*M* ammonia

C. 5.0*M* ammonia + 1.0*M* ammonium chloride

D. 1.0*M* acetic acid + 10M sodium acetate

E. 1.0*M* acetic acid

F. 0,05*M* nitric acid (HNO_3)

pK_a for acetic acid = 4.7

pK_b for ammonia = 4.75

$$K_w = 1 \times 10^{-14}$$

log 5 = 0.6990

WHEN YOU HAVE COMPLETED THIS SECTION, GIVE YOUR ANSWERS TO YOUR INSTRUCTOR FOR HIS EVALUATION.

STUDENT NAME: ______________________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #4 - #884 - HYDROLYSIS OF SALTS

SECTION ONE:

Classify the salts listed below into one of the following four classes according to the kind of neutralization reaction which produces them.

A. strong acid - strong base
B. weak acid - weak base
C. strong acid - weak base
D. weak acid - strong base

1. __A__ sodium chloride (NaCl) (Example)

2. ______ ammonium phosphate $(NH_4)_3PO_4$

3. ______ sodium cyanide NaCN

4. ______ potassium acetate CH_3CO_2K

5. _____ calcium nitrate $Ca(NO_3)_2$

6. ______ barium formate $(HCO_2)_2Ba$

7. _____ ammonium perchlorate NH_4ClO_4

8. _____ methylaminium sulfate $(CH_3NH_3)_2SO_4$

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 12.

SECTION TWO:

1. Hydrated metal cations often behave as weak bronsted acids. Which of the following hydrated ions would you expect to be very weak acids and which relatively strong weak acids?

Check the appropriate column.

Ion	Very Weak	Relatively Strong
Na^+		
Ca^{2+}		
K^+		
Ba^{2+}		
Cr^{3+}		
In^{3+}		

2. Which of the following common anions are very weak bases and which are relatively strong?

Check the appropriate column.

Ion	Very Weak	Relatively Strong
I^-		
NO_3^-		
Cl^-		
$CH_3CO_2^-$		
PO_4^-		

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 21

SECTION THREE:

Which of the following solutions will have pH, greater than 7 (>7), less than 7 (<7) or neutral ($pH = 7$)?

1. __________ potassium nitrate KNO_3
2. __________ potassium cyanide KCN
3. __________ aluminum nitrate $Al(NO_3)_3$
4. __________ sodium acetate CH_3CO_2Na
5. __________ potassium perchlorate $KClO_4$
6. __________ ammonium chloride NH_4Cl

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 30.

SECTION FOUR:

1. K_a for formic acid (HCO_2H) is 2×10^{-4}. Calculate K_H for the formate ion (HCO_2^-) and write the equation for the hydrolysis reaction.

($K_w = 1 \times 10^{-14}$ at 25°C.)

2. Calculate the pH of a 2$\underline{M}$ sodium formate solution at 25°C.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 40.

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #4 - #884 HYDROLYSIS OF SALTS END OF PACKET QUIZ

FINAL EXERCISE:

1. Predict the pH of the following solutions:

7, 7 or 7

______ K_3PO_4

______ NH_4ClO_4

______ KI

______ $(Al)_2(SO_4)_3$

______ $CH_3CO_2NH_4$ (ammonium acetate)

______ KCN

2. Give the hydrolysis equation for KCN

KCN has a K_a value of 5×10^{-10}

Calculate the pH of a 5M solution of KCN ($K_w - 1 \times 10^{-14}$ at $25^{o}C.$)

WHEN YOU HAVE COMPLETED YOUR ANSWERS, GIVE THE EXERCISE TO YOUR INSTRUCTOR FOR HIS EVALUATION.

STUDENT'S NAME: ______________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #5 - #885 - POLYPROTIC ACIDS AND SOLUBILITY

SECTION ONE:

Carbonic acid (H_2CO_3) is diprotic. Give the chemical equations for the two ionizations.

1st ionization ____

2nd ionization ____

$Ka(1) = 5 \times 10^{-7}$

$Ka(2) = 6 \times 10^{-11}$

Calculate the pH of a 0.02M solution

What is the carbonate concentration ($CO_3^{=}$) in this solution?

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 14.

SECTION TWO:

Write the equilibrium constant expressions for the hydrogen sulfide ionizations.

1st ionization: $H_2S + H_2O = H_3^{+}O + HS^{-}$

$K_a(1) =$ ____________________

2nd ionization: $HS^{-} + H_2O = H_3^{+}O = S^{=}$

$K_a(2) =$ ____________________

Now write the equilibrium constant expression for the net reaction.

Net reaction: $H_2S + 2H_2O = 2H_3^{+}O + S^{=}$

$K_{net} =$ ____________________

Multiply $K_a(1)$ by $K_a(2)$ and compare with K_{net}

$K_a(1) \times K_a(2) =$ __________ x __________

= __________

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 17.

SECTION THREE:

Calculate the $[S^{=}]$ in a 0.01M solution of H_2S which is 0.01M hydrochloric acid.

$K_a(1) = 1 \times 10^{-7}$, $K_a(2) = 1.1 \times 10^{-12}$

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 20.

SECTION FOUR:

1. Bismuth sulfide (Bi_2S_3) is sparingly soluble salt

   The solubility equilibrium is:

   $$Bi_2S_3(s) = 2Bi^{3+} + 3S^{=}$$

   Give the expression for its solubility product.

2. Write the solubility equilibrium for aluminum hydroxide $Al(OH)_3$ and give the expression for its solubility product.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 25.

SECTION FIVE:

1. The solubility of barium sulfate ($BaSO_4$) is 0.00699 g/l.

   Calculate K_{sp} for barium sulfate (mol. wt. $BaSO_4 = 233$).

2. Calculate the solubility in grams per liter of $BaSO_4$ in 0.01M H_2SO_4.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 31.

SECTION SIX:

Formulas: $pH + pOH = 14$
$pOH = -\log [OH^-]$

1. A solution has a pH of 8

   Calculate the hydroxide ion concentration of this solution.

2. The pH of a solution containing 0.1M magnesium chloride is adjusted to 8. Will magnesium hydroxide ($Mg(OH)_2$) be precipitated?

   Product of ion concentrations

   $$[Mg^{2+}] \times [OH^-]^2$$

   $$= [\qquad\qquad] \times [\qquad]^2 = \underline{\qquad\qquad\qquad}$$

   $K_{sp}\ Mg(OH)_2 = 1.5 \times 10^{-11}$

   Compare production of ion concentrations with K_{sp}

   Greater ☐ Less ☐

SECTION SIX: (cont.)

Will precipitation of $Mg(OH)_2$ occur?

Yes ☐ No ☐

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 39

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #5 - #885 - POLYPROTIC ACIDS AND SOLUBILITY - END OF PACKET QUIZ

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1. Oxalic acid ($C_2O_4H_2$) is a diprotic carboxylic acid. Give the chemical equations for the two ionizations.

1st ionization ______________________________

2nd ionization ______________________________

Write the equilibrium expressions for the two ionizations.

$K_a(1)$

$K_a(2)$

2. Give the K_{sp} equilibrium expression for the following sparingly soluble salts: $Al(OH)_3$, PbI_2. AgBr, Bi_2S_3.

WHEN FINISHED HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION.

STUDENT'S NAME: ______________________

Tm-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #6 - #886 TITRATION CURVES AND INDICATORS - SELF QUIZZES

SECTION ONE:

1. Calculate the equivalent weights of the following acids and bases:

(Atomic weights: C = 12; O = 16; H = 1;
Cl = 35.5; N = 14; K = 39)

A. CH_3CO_2H (acetic acid)

B. $HClO_4$ (perchloric acid)

C. $H_2C_2O_4$ (oxalic acid - dibasic)

D. NH_3 (ammonia)

E. KOH (potassium hydroxide)

2. How many equivalents in each of the following masses?

A. 30 g acetic acid

B. 7.0 g potassium hydroxide

3. Calculate the normality of the following solutions:

A. 30 g acetic acid in 200 ml of solution.

B. 7.0 g potassium hydroxide in 100 ml of solution.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 12.

SECTION TWO:

1. Calculate the number of equivalents in the following solutions:

A. 2.5 1. 0.10 N NaOH ______________________________

B. 10 1. 0.20 N H_2SO_4 ______________________________

C. 500 ml 0.50 N HCL ______________________________

2. Calculate the number of milliequavalents in the following solutions:

A. 25ml 0.50N NH_3 solution ______________________________

B. 50ml 0.20N $HClO_4$ ______________________________

C. 1.0 1. 1.0 N NaOH ______________________________

3. 20 ml of 0,2 N NaOH react exactly with 15 ml of an HCl solution. Calculate the normality of the HCL solution.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 17.

SECTION THREE:

FILL IN THE BLANKS:

1. An acid-base color indicator is either a weak ____________ or a weak ________________.

2. The protonated form of an indicator is a different _________________ ______________ from the unprotonated form.

3. Acid-base indicators are added to solutions in ______________________ __________________ quantities.

4. An acid-base indicator changes color over a pH range of about _________________________ units.

5. The pK value of an indicator is about the ____________________ -point of its range. The range of bromothymol blue is 6.0 to 7.6, so a rough estimate of its pK-value is _______________________________.

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 27.

SECTION FOUR:

Sketch the pH titer curve for the titration of a weak acid (such as acetic acid) with a strong base.

Which of the following indicators would be suitable for this type of titration?

Indicator	Acid Color	pH range	Basic color
Thymol blue	pink	1.2 - 2.8	yellow
Brom-phenol blue	yellow	3.0 - 4.7	violet
Methyl orange	pink	3.1 - 4.4	yellow
Brom-cresol green	yellow	4.0 - 5.6	blue
Brom-cresol purple	yellow	5.2 - 6.8	purple
Litmus	red	4.7 - 8.2	blue
phenolphthalein	colorless	8.3 - 10.0	pink
Alizarin yellow G	colorless	10.1 - 12.1	yellow

WHEN YOU HAVE COMPLETED YOUR ANSWERS, RESTART THE TAPE AND ADVANCE TO FRAME 38

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET # 6 - #886 TITRATION CURVES AND INDICATORS END OF PACKET QUIZ

1. Sketch the pH versus titer curve for the titration of a strong acid with a weak base. (For example: HCl with NH_3.)

2. Which of the following indicators would be suitable for this type of titration.

Indicator	*acid color*	*pH range*	*basic color*
Thymol blue	*pink*	*1.2 - 2.8*	*yellow*
Brom-phenol blue	*yellow*	*3.0 - 4.7*	*violet*
Methyl orange	*pink*	*3.1 - 4.4*	*yellow*
Brom-cresol green	*yellow*	*4.0 - 5.6*	*blue*
Brom-cresol purple	*yellow*	*5.2 - 6.8*	*purple*
Litmus	*red*	*4.7 - 8.2*	*blue*
Phenolphthalein	*colorless*	*8.3 - 10.0*	*pink*
Alizarin yellow G	*colorless*	*10.1 - 12.1*	*yellow*

3. Sketch the pH versus titer curve for the titration of a weak acid with a weak base. (Example: acetic acid with ammonia.)

Why are acid-base indicators unsuitable for signaling the end-point of this type of titration?

4. How many milliequivalents in the following volumes of solution?

A. 25 ml 0.20 N HCl
B. 20 ml 0.20 N NaOH
C. 50 ml 0.10 N H_2SO_4
D. 2.0 l. 0.10 N NH_3

5. How many milliliters of 0.10 N HCl react exactly with each of the following:

A. 50 ml 0.20 N NH_3
B. 10 ml 0.50 N NaOH
C. 100 ml 0.01 N $Ba(OH)_2$

6. For which of the above titrations (Question 5) would you use methyl orange for an indicator?

______________________ ______________________ ______________________

GIVE THE COMPLETED EXERCISE TO YOUR INSTRUCTOR FOR HIS EVALUATION.

STUDENT'S NAME: ______________________

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
PACKET #7 - REDOX AND ELECTROCHEMISTRY END OF PACKET QUIZ

1. ____ Which reaction is an example of oxidation? A. $Cu^{+2} + 2e^- = Cu$; B. $CO_3^{-2} + H_2O = HCO_3^- + OH^-$; C. $Fe^{-2} = Fe^{+3} + e^-$; D. $CaCO_3 = CaO + CO_2$

2. ____ Which of the following is the strongest oxidizing agent?

A. O_2; B. I_2; C. Au^{+3}; D. Ag^+

3. ____ Which of these is the strongest reducing agent?

A. K; B., Sn^{+2}; C. Fe^{+2}; D. Cl^-

4. ____ When Fe^{+2} acts as a reducing agent, its conjugate oxidizing agent is:

A. Fe; B. Fe^{+2}; C. Fe^{+3}; D. Fe^{-2}

5. ____ Which of the following is not an oxidizing agent?

A. Sn^{+2}; B. Fe^{+2}; C. I^-; D. NO_3^-

6. ____ In the reaction $Ni_{(s)} + 2Ag^+_{(aq)} = Ni^{+2}_{(aq)} + 2Ag_{(s)}$, the oxidizing agent is:

A. Ni^{+2}; B. Ag; C. Ag^+; D. Ni

7. ____ If free copper reacts with a solution of silver nitrate, the species reduced is:

A. Cu; B. Cu^{+2}; C. Ag; D. Ag^+

8. ____ Which species can behave as either an oxidizing agent or a reducing agent?

A. Ni^{+2}; B. Sn^{+2}; C. Fe^{+3}; D. Hg^{+2}

9. ____ In the reaction between metallic copper and nitric acid:
$Cu_{(s)} + 2NO^-_{3(aq)} + 4H^+_{(aq)} = Cu^{+2}(aq) + 2NO_{2(g)} + 2H_2O$, the reducing agent is:

A. Cu; B. H^+; C. NO_3^-; D. NO_2

10. ____ Which of the following correctly represents the reduction of lead (II) ion?

A. $Pb^{+4} + 2e^- = Pb^{+2}$; B. $Pb = Pb^{+4} + 2e^-$; C. $Pb^{+2} = Pb^{+4} + 2e^-$;

D. $Pb^{+2} + 2e^- = Pb$

11. ____ Which of the following is not a correctly written half-reaction?

A. $Fe^{+2} = Fe + 2e^-$; B. $Cr^{+3} + 3e^- = Cr$; C. $Cl^- = \frac{1}{2}Cl_2 + e^-$;

D. $Sn^{+4} + 2e^- = Sn^{+2}$

---

12. ____ In the reaction $MnO_2 + 4HCl = MnCl_2 + Cl_2 + 2H_2O$, the species oxidized is:

A. chlorine; B. chloride ion; C. manganese dioxide; D. manganese ion

13. ____ The oxidation number of the Cl atom in ClO_3^- is:

A. +1; B. +3; C. +5; D. +7

14. ____ An acidified solution of $K_2CR_2O_7$ is:

A. an oxidizing solution; B. a reducing solution; C. neither an oxidizing nor a reducing solution; D. a melly solution

15. ____ Which of the following is the most unlikely to be oxidized?

A. SO_4^{-2}; B. Br^-; C. Ag^+; D. H_2O

16. ____ Which of the following is the most likely to be oxidized?

A. $Mg_{(s)} + HCl_{(aq)}$; B. $Cu_{(s)} + Ag^+_{(aq)}$; C. $K_{(s)} + H_2O_{(l)}$

D. $FeSO_{4(aq)} + Pb_{(s)}$

17. ____ The E^0 value for the reduction of copper (II) ion to free copper is:

A. +0.16 volt; B. -0.16 volt; C. +0.34 volt; D. -0.34 volt.

18. ____ The E^0 value for the half-reaction $H_2O + e^- = \frac{1}{2}H_2 + OH^-$ is:

A. -1.66 volts; B. +1.66 volts; C. 0.83 volt; D. -0.83 volt

19. ____ The net E^0 value for the oxidation of metallic silver by nitric acid is:

A. 0.16 volt; B. 0.80 volt; C. 0.96 volt; D. 1.76 volts

20. ___ Which chemical species will oxidize Cu to Cu^{+2}, but will not oxidize

Br^- to Br_2?

A. F_2; B. Fe^{+2}; C. O_2; D. Ag^+

21. ____ Which of these elements will not 'dissolve' in dilute HCl?

A. Cs; B. Ag; C. Mn; D. Co

22. ____ The oxidation number of the arsenic atom in H_3AsO_4 is:

A. -1; B. -3; C. +3; D. +5

---

23. ____ A strip of metallic aluminum is placed in an aqueous solution of $Cu(NO_3)_2$. Which is not a product of the reaction that takes place?

A. Cu; B. Al^{+3}; C. NO; D. NO_3^-

24. ____ The E^0 value for the half-reaction $2Ni = 2Ni^{+2} + 2e^-$ is:

A. -0.23 volt; B. 0.23 volt; C. -0.46 volt; D. 0.46 volt

25. ____ Which of the following is not a possible reduction product of acidified nitrate ion?

A. NO; B. N_2O_5; C. NO_2; D. NH_3

26. ____ The E value for a standard $Cd/Cd^{+2}//Au/Au^{+3}$ ELECTROCHEMICAL CELL is:

A. -0.40 volt; B. 1.02 volts; C. 1.42 volts; D. 1.82 volts

27. ____ If the defined standard for E^0 values were: "Let the reaction $Ag = Ag^+ + e^- = 0.00$ volt," the E^0 for the half-reaction $Co = Co^{+2} + 2e^-$ would be:

A. 0.28 volt; B. 0.52 volt; C. 1.08 volts; D. 1.36 volts

28. ____ In the electrochemical cell $Sn/Sn^{+2}//Hg/Hg^{+2}$, electrons move from:

A. Sn to Hg; B. Sn^{+2} to Hg^{+2}; C. Hg to Sn; D. Hg^{+2} to Sn^{+2}

29. ____ In the half-reaction $Mg = Mg^{+2} + 2e^-$, as the concentration of Mg^{+2} ion is lowered the E value:

A. increases; B. decreases; C. remains the same

30. ____ How might one increase the voltage delivered by the $Zn/Zn^{+2}//Cu/Cu^{+2}$ electrochemical cell?

A. increase the $[Zn^{+2}]$; increase the $[Cu^{+2}]$
B. decrease the $[Zn^{+2}]$; increase the $[Cu^{+2}]$
C. decrease the $[Zn^{+2}]$; decrease the $[Cu^{+2}]$
D. increase the $[Zn^{+2}]$; decrease the $[Cu^{+2}]$

31. ____ As the ΔE for an electrochemical reaction becomes more positive, the ΔG for this reaction becomes:

A. more positive; B. more negative; C. unchanged

32, ____ Which equation correctly represents the change MnO_4^- to MnO_2 in basic solution?

A. $MnO_4^- + 4OH^- = MnO_2 + 2H_2O + 3e^-$

B. $MnO_4^- + 4H^+ + 3e^- = MnO_2 + 2H_2O$

C. $MnO_4^- + 2H_2O + 3e^- = MnO_2 + 4OH^-$

D. $MnO_4^- + 4H^+ = MnO_2 + 2H_2O + 3e^-$

33. ____ In the change $Cr(OH)_3 + HO_2^- + CrO_4^{-2} + H_2O$ (not balanced), which of these changes in oxidation state is occurring?

A. Cr^{+3} to Cr^{+4}; B. O^{-1} to O^{-2}; C. Cr^{0} to Cr^{+7}; D. O^{0} to O^{-1}

34. ____ In the electrolysis of aqueous NaCl, the substance formed at the negative electrode (cathode) is:

A. Cl_2; B. Na; C. H_2; D. O_2

35. ____ In the electrolysis of aqueous Na_2SO_4, the substance formed at the anode is:

A. Na; B. SO_2; C. O_2; D. H_2

36. ____ The number of moles of electrons required to produce 9 g of Al by electrolysis of $Al_2O_{3(l)}$ is:

A. 1; B. 2; C. 3; D. 4

37. ____ In the electrolysis of concentrated brine solution, the amount of chlorine produced by 1 faraday is:

A. ¼ mole; B. ½ mole; C. 1 mole; D. 2 moles

38. ____ A certain amount of electricity deposited 12 g of Mg. The same amount of electricity would deposit:

A. 4 g of H_2; B. 23 g of Na; C. 27 g of Al; D. 32 g of O_2

39. ____ In the change NO_3^- to NO, the number of equivalents in 1 mole of NO_3^- ion is:

A. 1/3; B. 3/2; C. 1; D. 3

40. ____ A solution of $KMnO_4$ is labeled 0.15M. If you know that the change will be MnO_4^- to Mn^{+2}, then the normality of this solution is:

A. 0.03N; B. 0.075N; C. 0.15N; D. 0.75N

TM-9 ACID-BASE, REDOX AND ELECTROCHEMISTRY
END OF MODULE TEST

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1. Show the step-wise dissociation of orthophosphoric acid into a hydronium ion and appropriate anions.

$$H_3PO_4 + H_2O \longrightarrow$$

2. Show the autoionization of water.

$$H_2O + H_2O \rightleftharpoons$$

3. A certain solution has a pH of 3.89. Find pOH and $[OH^-]$.

4. Find the hydronium ion concentration of 0.1M acetic acid. $K_a = 1.75 \times 10^{-5}$.

5. A 50ml solution of sulfuric acid was found to contain 0.490 g of H_2SO_4.

This solution was titrated against a sodium hydroxide solution of unknown concentration. 12.5 ml of the acid solution was required to neutralize 20 ml of the base. What is the concentration of the NaOH solution?

6. Construct a galvanic cell based on the reaction: $3Fe_{(s)} + 2Au^{3+} \longrightarrow 3Fe^{3+} + 2Au_{(s)}$. You know that ΔH is negative.

7. How much electricity will be required to decompose 500 g of water by electrolysis?

8. Balance the following reaction in basic aqueous solution.

$$SO_3^{2-} + CrO_4^{2-} \qquad\qquad SO_4^{2-} + Cr(OH)_3$$

9. How many coulombs of electricity are required to plate out 50 g of copper in aqueous solution?

10. The Daniell cell was made of a 'crowfoot' of solid zinc in a dilute zinc-sulfate solution and within a porous cup filled with copper sulfite was a copper electrode. Describe how it works and show the equation for the reaction.

WHEN FINISHED HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________________

DATE: ______________________________

TM-10 CELL CHEMISTRY & STRUCTURE

PURPOSE: To encourage the student to understand the biochemistry of the cell and to relate this chemistry to cell structure.

MATERIALS:

1. Asimov, I. THE CHEMICALS OF LIFE. The New American Library.

2. Barker. UNDERSTANDING THE CHEMISTRY OF THE CELL. Crane, Russak & Co., Inc.

3. Bordwell, F.G. ORGANIC CHEMISTRY. The MacMillan Co.

4. Conn, E.E. and Stumpf, P.K. OUTLINES OF BIOCHEMISTRY. John Wiley & Sons.

5. Larner, J. INTERMEDIARY METABOLISM AND ITS REGULATION. Prentice-Hall, Inc.

6. Kensal, E.V.H. PHYSICAL BIOCHEMISTRY. Prentice-Hall, Inc.

7. Krogman, D.W. THE BIOCHEMISTRY OF PLANTS. Prentice-Hall, Inc.

8. Edu-Lab Kit - Cell Structure

Eduquip-Macalaster Corp., 1085 Commonwealth Ave., Boston,
Massachusetts, 02215

OBJECTIVES: To enable the student to:

1. recognize the major cellular chemical groups

2. follow a metabolic pathway

3. recognize all structural parts

DATE STARTED: ________________

TM-10 CELL CHEMISTRY & STRUCTURE INSTRUCTION AND CHECKOFF LIST

This unit involves the reading of Barker's Understanding the Chemistry of the Cell and the use of the EDULAB KIT on Cell Structure. You will at the end of this unit understand the production and use of proteins, carbohydrates, and nucleic acids in cells. You will study the chemical reactions in cells, enzymes, respiration, and other 'living processes of chemistry'.

In the structural portion of this module you will study typical animal and plant cells, staining sections of living tissue and learn how to identify major cell organelles.

PACKET #1

LIVING CELLS AND THEIR COMPONENTS

Read the Preface and pages 1-26 in Barker, Understanding the Chemistry of the Cell. Complete programmed review. Make up 3" x 5" index cards of all new terms, concepts, etc., that you may come across. Have you made up a Data Storage Card as yet?

Date completed: ________________
Instructor Signature: ________________

PACKET #2

REACTIONS, ENERGY RELATIONSHIPS, AND CHEMISTRY OF LIVING PROCESSES.

Read page 27-60 in Barker, Understanding the Chemistry of the Cell. Complete Programmed Review.

Date completed: ________________
Instructor Signature: ________________

PACKET #3

CELL STRUCTURE

Complete the section from the EduLab Kit on Cell Structure. Use kritter sheets for your work. Show instructor all of your slides. DO NOT WRITE ON THE FORMS IN THIS PACKET. Submit your slides and kritter sheets for review and credit to instructor. Submit, when completed, the discussion questions at the end of the packet, page S-7.

Date completed: ________________
Instructor Signature: ________________

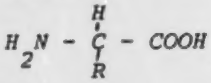
REQUEST END OF MODULE TEST.

END OF MODULE TEST: ____________ KRITTER SHEETS: ____________

SLIDES: ____________ DATA STORAGE CARDS: ____________

DATE COMPLETED: ____________

TM-10 CELL CHEMISTRY & STRUCTURE
PACKET #1 UNDERSTANDING THE CHEMISTRY OF THE CELL
PROGRAMMED REVIEW.

1. The simplest living system capable of independent existence is a __________. Viruses are smaller and simpler but cannot live __________. Bacteria are no __________ complex than other organisms are but they have a remarkable capacity for chemical __________. When teased out of tissue cells from complex higher animals and plants, they can be grown in __________ __________ by a process called cloning.	
2. The majority of living organisms require at least part of their food in organic form and are __________, but, chlorophyllaceous organisms can make their own food and are termed __________. It is possible that many of the compounds we regard as biological existed on the earth before the advent of __________. These compounds were produced and reproduced in the __________-__________ world.	1. bacteria independently less synthesis tissue culture
3. The amino acids possess both __________ and __________ groups and exhibit __________ and __________ properties. The basic symbol for an amino acid is __________. The "R" group changes for each of the over __________ amino acids. Typical "R" groups are: __________, __________, __________, & __________.	2. heterotrophic autotrophic life non-living
4. At both low and high pH amino acids are highly __________. They can act then as __________ or __________. Combination between carboxyl group and amino acid group produces __________. Very long peptides are called __________.	3. amino carboxyl acidic basic  $H_2N-\overset{H}{\underset{R}{C}}-COOH$ 20 NH_2 COOH OH SH
	4. ionized acids bases peptides polypeptides

TM-10 CELL CHEMISTRY & STRUCTURE
PACKET #1 (cont.)

5. The side-chains of some "R" groups contain hydroxyl and thiol groups which cross-link to produce protein __________. Conformations are controlled especially by __________bridges. Shape of wrapped protein strands is controlled by __________bonding.	
6. Biochemicals with the general formula $C_x(H_2O)_4$ are called __________. Most single unit structures exist in nature in 5 and 6 __________ chains or in rings containing an __________ atom. These basic units can __________ di-, tri-, tetra- and poly-__________. The general term for a single unit is an __________.	5. structure disulfide hydrogen
7. Individual monosaccharides differ less frequently in the nature of the functional __________ than in their __________ in space. The key to understanding large carbohydrates is the __________ reaction.	6. carbohydrates carbon oxygen polymerize saccharides aldose
8. When glycoside bonds are formed with glucose and fructose __________ is produced in which carboxyl groups are __________. Sucrose is a good __________ chemical. When galactose and glucose react they form __________ which like __________ is 'wide-open' to further linear bonding. Arthropod exoskeletons are rich in __________.	7. group distribution glycoside
9. The repeating structural units in nucleic acids are __________. All nucleotides contain __________ __________ __________ __________, __________ __________ and __________ __________. The two main families of nucleotides are those containing D-__________ and D-2- __________. The compounds involved in energetic reactions in the cell are __________ and __________.	8. sucrose protected d storage lactose cellulose chitin
	9. Nycleotides nitrogen containing ring compounds carbohydrate residue phosphate group ribose deoxyribose ADP ATP

10. Polynucleotides are always built up from either __________ or __________, but NEVER contain both types in one __________. Now we see why these exist: __________ and __________; throughout our studies of genetics.	
11. Hydrogen bonds in the nucleic acids are formed between __________ of basic __________; cytosine being linked to __________; while adenine links to either __________ or __________. Always, A= __________, and G= __________ in percent composition.	10. ribonucleotides deoxyribonucleotides chain RNA DNA
12. Variations of composition of DNA of DIFFERENT ORIGIN, (e.g., species of actinomycetes or species of liverworts) are confined to differences in A & T relative to __________. Here then is a superb method for use in __________.	11. pairs residues quanine uracil thymine T C
13. The most frequent food molecule is __________. Another name for glucose is __________. The volume of CO_2 produced divided by the volume of oxygen consumed (both at S.T.P.) gives the __________. S.T.P. means __________ __________ & __________. The device used in respiratory studies is the __________ __________.	12. G & C Taxonomy
14. The elements __________, __________ and __________ DO NOT contain a proportion of isotopic atoms which differ from normal atomic weight. Isotopically labeled hydrogen, nitrogen and __________ are commonly used to trace reactions in living cells. The time course of the __________ of isotope into precursor and __________ when followed makes it possible to establish sequence in biochemical reaction series.	13. glucose dextrose R.Q. (respiratory quotient) Standard Temperature and Pressure (0^{o}Celsius, 1 atmosphere pressure) Warburg apparatus
	14. sodium phosphorus iodine carbon incorporation product

15. It is possible to recognize metabolic intermediates by monitoring animal __________ because if an inherited mistake causes an __________ to be missing the chemical __________ a given reaction accumulates in the urine or excreta. Two genetic diseases which have helped elucidate human metabolic pathways are __________ and __________.	
16. Most bacteria are able to __________ all the nitrogen containing materials they need if they are supplied with __________ salts and an organic source of __________. Genetic abnormalities in bacteria can be found by using media which supplies all amino acids except one. The method of __________ plating can detect instant strains.	15. excreta enzyme preceding alkaptonuria pentosuria
17. Sulphanilamide was found to inhibit the last stage in the production of the __________ ring. This is a typical __________ means of blocking enzymatic reactions.	16. synthesize ammonium carbon replica
18. If certain bacteria are grown in a solution containing acetic acid labeled __________, it is found that __________ acid accumulates. This is an example of __________ __________.	17. purine artificial
19. Formic acid serves as a carbon source in the formation of the __________ ring. The five carbon unit is called the __________ unit. Products of combined isoprenoid units are: __________, __________ and __________.	18. radioactively (with ^{14}C) butyric biogenesis study
20. Biological materials fall into __________ groups. The living cell makes multitudes of chemical from a minimum of __________.	19. purine isoprenoid latex vitamin A cholesterol
	20. biogenetic precursors

TM-10 CELL CHEMISTRY & STRUCTURE
PACKET #2 UNDERSTANDING THE CHEMISTRY OF THE CELL
PROGRAMMED REVIEW pgs. 27-60

1. Cell fragments are prepared by disrupting the tissue using: __________, __________, __________, and __________. Fractions are prepared in centrifuges. Ordinary centrifuges operate at up to __________g's. Above this they are called __________.	
2. Efficiency of separation can be checked chemically. Chloroplasts should have a high percent __________; nuclei have __________; mitochondria __________; dehydrongenase and lysosomes have ribonuclease, phosphatase, and __________ enzymes.	1. grinding homogenizing pressurizing vibrating (with ultrasonic waves) 100,000 ultracentrifuges
3. An enzyme name has three parts: it specifies the __________, it indicates the nature of the reaction; __________; and it has the suffix __________, which is only used for __________.	2. chlorophyll DNA glutomic proteolytic
4. Esters (like glucono-B-lactone) are formed between __________ groups and __________ groups. Notice that in the oxidation of glucose oxygen does not enter the molecule of the completed glucono-B-lactone. Where does the oxygen appear? __________ "It is for this reason that the name glucose __________ is preferred to glucose oxidase."	3. substrate catalyzed -ase enzymes
5. When glucose dehydrogenase is decomposed it loses its __________activity. The colorless portion is a complex __________, while the yellow portion is not a protein but rather is FAD, named __________-__________ __________. This is the so-called __________-__________. FAD serves as a __________ carrier in many biochemical reactions. In other dehydrogenations, the closely related compounds FMN, NAD, or NADP is required to carry __________.	4. carboxyl hydroxyl in the hydrogen peroxide dehydrogenase
	5. enzyme protein flavin-adenine dinucleotide co-factor hydrogen hydrogen

6. Oxidation of glucose usually is preceded by its conversion to __________. For this reaction the enzyme __________, __________ co-factor, __________ substrate and __________ ions are all required.	
7. When separating large and small molecules several techniques are utilized. For ionized molecules __________-__________ chromatography is preferred. Carbohydrates and hydroxylic compound are separated using __________ chromatography. Fatty acids are separated using adsorption on inert __________, like Kieselguhr or fine ground __________. Very heavy long-chain fatty acids respond to __________-__________ chromatography.	*6. glucose-Beta-phosphate glucokinase ATP NADP magnesium*
8. Large and small molecules can often be separated by gel filtration of __________ chromatography (figure 4-2). By careful calibration of __________, molecular weights or percolated molecules can be judged.	*7. ion-exchange paper solids silica vapor-phase*
9. The solubilities of proteins in aqueous solution vary considerably according to availability of other __________. If a __________, such as, NH_4SO_4 is added to solubilized protein it will often __________. Lowering the amount of solvent by adding another __________ (like alcohol) can selectively __________ on protein out from a mixture of __________.	*8. sieve porosity*
10. Glucose can in most cells be split via the anaerobic process of __________ or changed to CO_2 via the process of __________. In the anerobic process (glycolysis) each six-carbon unit ultimately yields only two units of __________. Note that oxidation occurs without any __________. In muscle tissue the end product is toxic __________ __________, while in yeast the toxic product __________ is formed. In yeasts the glycolysis reaction is called __________.	*9. solutes salt precipitate solvent precipitate protein*
	10. glycolysis respiration ATP oxygen lactic acid ethamol fermentation

11. When in 1937, H.A. Krebs utilized the __________ apparatus to study __________ he found that acids produced and used were re-formed __________. A reaction pathway now called the Krebs of __________-__________ cycle emerged.	
12. The salient features of this cycle are : 1) The participation of __________ acid in the formation of citric acid from __________ acid. 2) The formation of __________ molecules of CO_2 in the complete cycle of reactions. 3) The consumption of __________ molecules of NAD and one of __________. 4) The part played by oxygen in respiration is largely concerned with __________ of co-factors. 5) About __________ molecules of ATP are produced.	11. Warburg respiration alternately citric acid
13. In photosynthesis some form of __________ is required together with certain pigments such as B-__________. Higher plants accomplish photosynthesis in organelles called __________, while procaryotes utilize __________.	12. pyruvic oxaloacetic three two FAD regeneration forty
14. Chlorophyll consists of four __________ rings linked about a central __________ ion. Like most colored compounds the __________ in the highly resonant orbitals can be excited by incident light. The energy gathered by chlorophyll is used to split __________ molecules. While oxygen escapes directly through __________ or into the aqueous environment the hydrogen is taken up by __________ and the universal energy compound __________ formed.	13. chlorophyll carotene chloroplasts chromatophores
15. Carbon dioxide is drawn into plant and photobacterial biosynthesis by a devious route via __________, 1, 5-diphosphate and a cyclic regeneration process which ultimately results in the formation of __________.	14. heterocyclic magnesium electrons water stomates NADP ATP
	15. ribulose hexose

16. Muscle tissue not only needs the enzymes associated with glycolysis but also the proteins __________ and __________. By processes not fully understood these proteins are made to contract using energy from __________.	
17. The retina of the eye contains a pigment visual __________ or __________. This consists of a protein __________ and an aldehyde (vitamin A) called __________. A good source of this latter compound is liver or __________. The conversion of these compounds is by chemical __________, and is catalyzed by an enzyme __________.	16. actin myosin ATP
18. All lipids have one characteristic in common, a large non-__________, non-reactive end. They are generally non-__________. There are three basic kinds of lipids: __________ __________, __________ and __________. When lipids are hydrolyzed by __________ they yield __________ and a __________-__________ __________ __________ and then the glycerol can be 'burnt' biochemically for energy.	17. purple rhodopsin opsin retinal carrots isomerization cis-trans-isomerase
19. Control of passage through cell membrane is accomplished through enzymes called __________. Membranes are made of layers of __________ and an inner layer of __________. It is the polar __________ which can bond protein and lipid together in a fixed, controlled pattern.	18. polar ionizing glyceride fats steroids carotenoids lipases glycerol long-chain fatty acids
20. Amino acids are carried from place to place in the cell by messenger __________ __________ __________ __________. The sequence in which amino acids are accepted by the __________ is determined by a high molecular weight RNA called __________ ____.	19. permeases protein lipid phospholipids
	20. low molecular weight (soluble) RNA ribosomes messenger RNA

21. Transformation by DNA provides direct __________ evidence that the genetic __________ is associated with DNA in __________. DNA controls the synthesis of __________. The sequence of residues in a polypeptide is determined by a sequence of __________ in a molecule of __________.	
	21. experimental message bacteria RNA nucleotides RNA

NOTE: IF YOU HAVE NOT REVIEWED YOUR ORGANIC AND BIOCHEMISTRY DO SO WHEN YOU REVIEW THIS BOOKLET PRIOR TO TAKING THE END-OF-MODULE TEST.

Now go to cellular structure.

TM-10 CELL CHEMISTRY AND STRUCTURE
PACKET #3 - CELL STRUCTURE

This packet is designed to show you a sampling of typical cells, and to help you understand something about the structure and function of cells. Throughout the activity, you will be examining cells looking for various structures called organelles. A cell is made up of these specialized components - each organelle has a particular role in the life of the cell.

PART 1 - TYPICAL CELLS

You will need the following materials: microscope slides and cover slips, a toothpick, two (2) razor blades, a petri dish, and Lugol's solution.

Using the toothpick, gently scrape the inside of your cheek, and transfer the material to a glass slide. Gently drop a cover slip over the material, and GENTLY squeeze the cover slip using the eraser end of your pencil. Place the slide under the microscope, and focus on the material using low power, then high power. Make drawings below of what you see:

Place a drop of the Lugol's solution on the slide next to the cover slip. Place the piece of filter paper next to the cover slip on the side opposite to the drop of stain, and draw the stain under the cover slip. Focus the slide under high power, and make a drawing of what you see:

You probably noticed that you could see considerably more detail after staining the cells with the Lugol's solution. This is the reason that biologists use stains in their study of cells.

Within each of the cells is a darkly stained object which is either

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round or oval in shape. This is the nucleus. The nucleus is the control center of the cell, and contains a molecule called DNA. This molecule contains a chemical code for all of the activities of the cell. The code is transferred from the DNA into molecules of protein. Each protein performs a different task in the cell.

If you look closely, you will probably notice that within the nucleus is a very small area which is darker than the rest of the nucleus. This is the nucleolus, and is active in the cell's manufacture of protein. The nucleolus makes small objects called ribosomes which then manufacture the proteins. Ribosomes are too small to be seen with a light microscope, but scientists can see them with an instrument called an electron microscope. Perhaps you have a picture of ribosomes in your text or reference book.

Look at the material outside of the nucleus - this is referred to as the cytoplasm. You should be able to see many small objects within the cytoplasm. These objects are referred to as the organelles of the cell. Cheek cells have several types of organelles: mitochondria, golgi apparatus, inclusions, endoplasmic reticulum and lysosomes. Label the parts you see on your drawings.

Locate a piece of potato, and place it in the plastic dish. CAREFULLY using the razor blade, make as thin a slice as you can near the outer edge of the potato, including the skin. Try several times to get a piece which you can almost see through. Carefully transfer the slice to a clean glass slide, and place a cover slip on it. Focus under low and high power, and make a drawing of what you see:

Using the same technique as with the cheek cells, add a drop of Lugol's iodine to the slide. What do you notice, even before you examine the slide under the microscope?

Make a drawing of what you see under high power: (label the nucleus and nucleolus, if you are able to locate them)

In addition to the nucleus and nucleolus, several new features are present. Notice that each cell is surrounded by a band of material. This is called the cell wall, and it is found only in plant cells. Within each cell, you probably notice that there are several rounded or oval objects which are bluish in color. These are starch grains, and are similar to inclusions in animal cells. They store the starch which the plant has made.

If the potato which you are working with is a very fresh one, you may have noticed some small green objects in the cells near the skin of the potato called chloroplasts.

To see the chloroplasts better, locate a piece of the aquarium plant Elodea. Tear off one of the leaves, and place the leaf on a glass slide. Add a drop of aquarium water and a cover slip, and focus the slide under medium power on high power. What do you notice about the cells?

Make a drawing of the cell below. Label the nucleus, chloroplasts, cell wall, other organelles, and the large open region in the center of the cell called the vacuole. This is something like an inclusion, except that it stores primarily water.

What is cytoplasmic streaming? Show on drawing with arrows.

PART II - MEMBRANES

One very important part of the cell which you really cannot see with a light microscope is the cell membrance. The membrane must control the flow of material in and out of the cell. We can use the Elodea leaf to show how the cell responds to its environment.

Locate a bottle of solution called hypertonic saline. This is a fairly concentrated solution of salt in water. Since the Elodea lives in fresh water, it probably does not do very well in salt water. Let's see what happens.

Place a drop of the hypertonic saline next to the cover slip, and draw it under the slide with a piece of filter paper or paper towel.

Watch what happens to the flow of chloroplasts and cytoplasm within the cell as you add the saline solution. Describe your observations below.

You can see the same activity in animal cells. If your teacher directs, obtain an alcohol wipe and a sterile lancet, along with a clean glass slide and a clean cover slip.

Wash your hands with soap and water, and wipe them dry with a clean paper towel. If you are right-handed, perform the following procedure on your left hand; if you are left-handed, on your right hand. Wipe the end of your index, middle, or ring finger with the alcohol wipe. Tear open the sterile lancet package. Squeeze the end of the finger with your thumb, and quickly pierce the end of your finger with the lancet. Wipe off the first small drop of blood on the peper towel. Then add a drop of blood to the clean glass slide. Add a drop of isotonic saline, and drop a cover slip on the slide. Examine the slide under high power, and make a drawing of a few of the cells:

You will probably notice that these cells do not appear to have a nucleus or any organelles. Do not confuse the depression in the center of the cell with a nucleus. Red blood cells do not have nuclei; they are essentially membranes containing the molecule hemoglobin (which carries oxygen).

Using the techniques described previously, add a drop of hypertonic saline to the slide, using filter paper or paper toweling to draw it under the cover slip. Wait about a minute for the cells to settle down, then make a drawing of several of them.

Again, the membrane allowed water to escape from the cell, and the cell shrunk.

PART III - STAINING OF ORGANELLES

Wipe the same finger with the alcohol wipe, and squeeze it again to form another drop of blood. Place the drop on a clean slide. Hold another slide at 45° angle to the first, and quickly push the drop of blood across the slide. Let the drop dry, then place two (2) drops of Wright's stain on the slide. Let the stain sit for one (1) minute, then gently swish the slide in a beaker of water. Do not run the slide directly under the faucet. After the excess stain is removed, let the slide dry in the air. Do not add a cover slip, but place the slide directly under high power of the microscope. Look for cells other than the numerous red blood cells, and make a drawing of several of them:

In your diagrams above, label the nucleus, which in some of these cells may appear to be several nuclei. Notice also that the interior of the cell is filled with small granules, some of which may appear to be different shades of pink, blue, or purple. Some of these granules are inclusions, and some are the ***lysosomes****. These organelles allow these cells, which are called white book cells, to digest bacteria and other foreign invaders in the body. The lysosomes contain powerful enzymes which break down the bacteria. In other cells the lysosomes break down dead or damaged cell parts.*

Obtain a piece of fresh ***celery****, and cut a section about ½ inch long. Stand this section on end on a clean glass slide, and make a slice down through the celery as close to the outer edge as possible.*

Place this thin sheet, inner surface up, on the slide, and cut out the region from between two of the strands of the celery. Add a drop of Janus Green B stain to the piece of celery, and add a cover slip. Observe the cells under high power, and make a drawing of one typical cell:

Notice that some of the organelles in the cytoplasm have stained a pale bluish-green color. These are the ***mitochondria****. They are responsible for breaking down food and providing the cells with chemical energy. You*

---

may wish to make a slide of your cheek cells, or of a fresh drop of blood, and stain them with the Janus Green B. If you use the blood, simply add one drop of the stain to the drop of blood, and then add a cover slip. Try to locate the mitochondria in the white blood cells. This may require a bit of patience. Make a drawing of what you see:

We mentioned before that many cells contain a Golgi apparatus, and endoplasmic reticulum. These are both difficult to see with a light microscope, but your books may have pictures of these organelles. The endoplasmic reticulum, along with the ribosomes, is responsible for the manufacture of proteins. The endoplasmic reticulum and the golgi package and store the proteins for future use.

If you have time, you may wish to make slides of other types of cells, using the Lugol's and Janus Green B stains. Each time you make an observation, make and label a drawing of what you see.

DISCUSSION QUESTIONS

1) In terms of structure, what are the differences between plant and animal cells?

2) Heart muscle cells require a great deal of energy for their activity, while the cells of fat tissue are responsible for storing excess food in the body. What organelles would you expect these two types of cells to have in large numbers?

3) Why do you think that biologists use the wide variety of stains that they do (there are many hundreds of different stains and staining techniques)?

4) Where would you expect to find more chloroplasts, on the top or the bottom of a leaf, and why?

5) A new organelle is found in a cell. The organelle seems to manufacture starch when the cell is exposed to light. What organelle is the new one similar to?

6) Why do you think that organelles are important to the cell?

TM-10 CELL CHEMISTRY AND STRUCTURE
END OF MODULE TEST

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1) Proteins, peptides, and amino acids are related. Explain their relationship.

2) List and give structural formulae for ten (10) amino acids. (Use a 'kritter sheet'.

3) What is produced when amino acids link together? How does this happen?

4) How are peptides linked together? What bonding is important at this level of complexity?

5) Describe how you would classify carbohydrates?

6) Describe a typical nucleic acid.

7) What is a nucleotide? Where are they found and what do they perform?

8) What is a lipid? What is a phospholipid? When are they found?

TM-10 CELL CHEMISTRY AND STRUCTURE
END OF MODULE TEST (cont'd)

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9) *Draw a typical plant cell and label parts. You may use several drawings to show inner detail.*

10) *Draw a typical animal cell. You may use several drawings to show inner detail.*

NAME: ______________________________

DATE: ______________________________

EM-1 BACTERIAL ECOBIOLOGY

PURPOSE:

To illustrate a selection of biological properties of bacteria that reveal them as important living beings.

MATERIALS:

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EM-1 BACTERIAL ECOBIOLOGY (cont.)

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Stanier, R. Y. and vanNeil, C. B. The Concept of a Bacterium. Arch. Mikrobiol. 42:17.

Stotzky, G. Clay Minerals and Microbial Ecology. Trans. N. Y. Acad. Sciences. 30:1.

Swain, F. M. Paleomicrobiology. Ann. Rev. Microbiol. 23:455.

Thompson, D. On Growth and Form. (J. T. Bonner, ed.) Cambridge Univ. Press.

OBJECTIVES: To enable the student to:

1. recognize major bacterial form classes.
2. relate the microbial inhabitants to their environment.
3. view microbial life 'in situ'.
4. perform bacterial ecogiological studies.

DATE STARTED: ____________________

EM-1 BACTERIAL ECOBIOLOGY INSTRUCTION AND CHECK OFF SHEET

PACKET #1 - BACTERIA IN NATURE.
Read the first two chapters in Doetsch & Cook: Introduction to Bacteria and their Ecology. Ask for self-correcting quiz. Submit required F. I. D. sheets for review.

QUIZ & F.I.D. SHEETS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2 - FORM, FUNCTION, POPULATIONS & HABITATS.
Read Chapters 3 and 4 in Doetsch & Cook. Produced the required kritter sheets.

F. I. D. SHEETS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3 - CLAY MINERALS AND MICORBIAL ECOLOGY.
Read Stotzky's article: Clay Minerals & Microbial Ecology. Utilize the review questions provided by the instructor.

REVIEW QUESTIONS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4 - BACTERIAL ENERGETICS.
Read Chapter 5 of Doetsch & Cook. When completed ask for self correcting quiz. Hand in necessary F. I. D. sheets and terms.

F.I.D. SHEETS & TERMS: ____________________
CYCLE SHEETS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #5 - BACTERIA AS ENVIRONMENTAL DETERMINANTS.
Read Chapter 6 in Doetsch & Cook and the article by Silverman and Ehlich on Bacterial Degradation of Minerals. Also read the articles by Perfil'ev et. al. on Iron-Manganese deposits. Complete the assigned kritter sheets and questions and hand in to your instructor for his evaluation.

F.I.D. SHEETS: ____________________
QUESTIONS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #6 - MICROBES BY DIFFERENT SLIDE TECHNIQUES.
Utilize the buried slide, immersion slide and/or capillary slide techniques to view microbes in their natural environment. Draw and explain results over time on kritter sheets. Hand in slides and kritter sheets to instructor for his evaluation.

F.I.D. SHEETS & SLIDES: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

REQUEST END OF MODULE TEST.

END OF MODULE TEST: ____________ DATE COMPLETED: ____________

INSTRUCTOR SIGNATURE: ____________

EM-1 BACTERIAL ECOBIOLOGY
PACKET #1 - SELF-CORRECTING QUIZ

I. Methods of studying bacteria include (complete the following statements):

A. The immersion technique involves.....

B. The radio autographic method is used to......

C. The rate at which oxygen is utilized may be determined by.....

D. Radio respirometry is a new technique used to....

II. Name ten compounds normally occurring during degradation which bacteria will degrade.

A. B.

C. D.

E. F.

G. H.

I. J.

III. Name ten synthetic compounds which some bacteria will degrade (even though toxic to most creatures.

A. B.

C. D.

E. F.

G. H.

I. J.

IV. Reproduce Figure 2.3A for your F.I.D. notebook.

V. Reproduce Figure 2.4B and 2.5 and the necessary notes on CAPSULES for your F.I.D. notebook. You will learn about capsule staining in another module.

VI. Produce a detailed page or two of notes on pili and flagella for the F.I.D. notebook.

VII, Show the structural formulae for:

N-Acetylmuramic acid

Glucose

DAP

glycine

N-Acetylglucosamine

alanine

glutamic acid

lysine

SHOW THE BASIC MOIEITES FOR:

CELLULOSE

CHITIN

PEPTIDOGLYCAN

VIII. Reproduce Table 2.2. Note how important the Gram-stain is.

IX. Be sure to have notes for your F.I.D. notebook on the cytoplasmic membrane nucleus, ribosomes, endospores, cysts, conidia, myxospores, inclusions and rhapidosomes.

X. Utilize the references available and observe typical plates to become familiar with colony forms.

WHEN FINISHED WITH THESE QUESTIONS GO OVER THEM WITH YOUR INSTRUCTOR FOR CREDIT FOR THIS PACKET.

DATE COMPLETED: ____________________
NAME: ____________________

EM-1 BACTERIAL ECOBIOLOGY
PACKET #2 - FORM, FUNCTION, POPULATIONS AND HABITATS.

PRODUCE COMPLETE "DRITTER SHEETS" ON THE FOLLOWING ... USE BERGEY'S AND ALL OTHER AVAILABLE REFERENCES.

1. budding bacteria: *Hyphomicrobium* and *Rhodomicrobium*.
2. stalked bacteria: *Caulobacter*, *Ancalomicrobium* and *Prosthecomicrobium*.
3. ribbon-bacteria: *Gallionella*, *Nevskia*, *Simonsiella* and *Alysiella*.
4. fruiting-bacteria: *Mxyococcus*, *Chondromyces*, *Cytophaga* and *Sporocytophaga*.
5. Net-formers: *Pelodictyon*, *Thiothrix*, *Leucothrix*, *Vitreoscilla* and *Sphaerotilus*.
6. Sulfur-bacteria: *Beggiatoa*, *Chromatium*, *Thiospirillum* and *Thiobacillus*.
7. Filamentous-branching bacteria: *Nocardia*, *Actinomyces*, *Streptomyces*.
8. Cell wall-less bacteria: *Mycoplasma* sp. (What is an L-form?)
9. Flexible, helical bacteria: *Treponema*, *Leptospira*, *Cristispira*, and *Borrelia*.
10. Blue-green algae: (If you have started EM-15 on Algae you may combine tasks here.) Ten blue-green algae minimum. Note Figure 3-19 in Doetsch & Cook.
11. *Hydrogenomonas*
12. *Carboxydomonas*
13. The Methane bacteria.
14. The non-symbiotic nitrogen-fixing bacteria. (pg. 119-120, D. & C.)
15. The Luminescent and Photosynthetic bacteria.
16. Halophiles: *Halobacterium*

EM-1 BACTERIAL ECOBIOLOGY
PACKET #3 -CLAY MINERALS AND MICROBIAL ECOLOGY - REVIEW QUESTIONS

1. What are the physicochemical characteristics of clay minerals which affect microbial ecology?

   A.

   B.

   C.

   D.

   E.

   F.

   G.

2. What correlation was apparent when soils which produced bananas for long periods of time began to have disease set in?

3. Do eubacteria, fungi and actinomycetes act alike in the presence of certain clay minerals?

4. What types of studies did Stotzky undertake?

   A.

   B.

   C.

   D.

   E.

   F.

   G.

   H.

5. Why are such studies of possible practical importance?

EM-1 BACTERIAL ECOBIOLOGY
PACKET #4 - BACTERIAL ENERGETICS - SELF-CORRECTING QUIZ.

1. Produce a short explanatory essay utilizing Figure 5.1 to illustrate your understanding of Bacterial Metabolism. DO NOT COPY THE BOOK. Synthesize your own personal explanation. Then discuss with the instructor or the tutor.

2. If you do not already have the Tricarboxylic acid cycle in your notes (TM's 8 & 9) utilize Figure 5.2 to organize your thoughts. Discuss with the instructor when you can explain with the use of the cycle drawing each step.

3. Now prepare the same way for the electron-transport system.

4. On the appropriate F.I.D. sheets from PACKET #2 place the 'energetics' of each bacterial type as found in sections 5.4 through 5.12.

5. List any new technical terms under the bacterial section of your F.I.D. notebook. ARE THESE TERMS ON YOUR 3" x 5" cards as yet?

EM-1 BACTERIAL ECOBIOLOGY

PACKET #5 - BACTERIA AS ENVIRONMENTAL DETERMINANTS - REVIEW QUESTIONS

I. Explain why the earth's atmosphere is not made up of the elements most prevalent in the universe as a whole.

II. Reproduce from Figure 6.2 for your F.I.D. notebook and discuss briefly.

III. Reproduce Figure 6.3 for your F.I.D. notebook and discuss briefly.

IV. Reproduce Figure 6.1 for your F.I.D. notebook and discuss briefly.

V. Using the appropriate 'krittersheets' explain the origin of lime, sulfur, iron and manganese deposits.

VI. Form the Silverman-Ehrlich article list and explain the origin of some "heavy" metal deposits.

VII. Discuss the economic importance of microbial degradation of minerals.

EM-1 BACTERIAL ECOBIOLOGY
PACKET #6 - MICROBES BY DIRECT CONTACT TECHNIQUES

Direct methods of observing microorganisms in soil include microscopic examination of thin sections of undisturbed samples of soil; examination of smears of soil suspensions; and observation or isolation of organisms growing on glass slides injected into soil 'in situ'. The direct method often gives an estimate of the number of cells without cultivation of the organisms, thus avoiding the complicating factors of selection of media and environmental conditions necessary for growth 'in vitro'.

Some advantages of the direct methods are:

1. All cells can be counted.
2. Morphology can be seen.
3. Dimensions can be measured.
4. Spatial relationships between cells and other soil particles as they exist in the natural environment can be seen.

Some disadvantages are as follows:

1. Living and dead cells are hard to tell apart.
2. Similar organisms are difficult to identify further.
3. Filamentous organisms can be hard to count.
4. Representative soil samples can be difficult to obtain because very small amounts of soil can be used.

Isolation of organisms by direct methods is a challenging procedure, but isolation is required if further studies are to be made on the morphology and physiology of the observed organism. Most so-called direct isolation procedures employ a synthetic agar medium for proliferation of the organism. Single-cell isolations by microscopic techniques are not often used, probably because of the inherent difficulties in conducting the necessary operations in a medium where the mass of inert particles is so much greater than that of living particles; but this technique offers promise, especially in combination of other techniques.

CONTACT SLIDE TECHNIQUE

The original contact-slide technique involves observation of organisms adhering to a microscope slide that has been left for a time in contact with soil. The technique was proposed by Cholodny (1930) and Rossi et al. (1936) as a way of observing some of the characteristics of the soil population in relation to the environment. Accurate measurement of numbers of cells in soil cannot be made. Isolation of the organisms observed is difficult. Some organisms are more attracted to surfaces than others. Modifications include an impression-slide technique (Brown, 1958) to study a thin sample of the soil surface by coating the slide with adhesive to hold the soil particles. Cellulose decomposition was studied (Tribe, 1957) by placing a cellulose film on the face of the slide. Other materials, such *as nylon and glass cloth,have been used for burial. Isolation directly from soil is more commonly done by one of the trapping methods done by using agar media, as described by Johnson, et al. (1959).*

The objectives of the contact-slide technique is to observe the soil population in its natural state. Transfer of the organisms to a glass slide facilitates the observation because it eliminates most of the interference due to other soil particles. Pushing a glass slide against a fresh soil surface or crushing soil crumbs against the slide reveals only those organisms present at the time of sampling that will stick to the glass when dried. If the slide is buried for a time in the soil, both the organisms that stick to the glass and the organisms that develop on it can be observed. If careful technique is used, sporulating bodies will remain intact; observations may be made of colony characteristics; feeding of organisms on materials; and response of organisms to environmental factors, such as water films.

METHOD:

For this experiment you will need:

1. *Clean glass slides - thoroughly wash and flame just before use to ensure sterility.*
2. *Phenolic rose bengal:*
   Dissolve 1.0 g of rose bengal and 0.01 g or $CaCl_2 \cdot 2H_2O$ in 100 ml of 5% aqueous phenol.

PROCEDURE:

1. *Insert glass slide (sterile) vertically into soil sample leaving 1/2" above surface. Press soil gently against slide.*
2. *Incubate for one to three weeks.*
3. *After incubation, remove slide carefully, by breaking the slide away from the undisturbed side by moving the slide parallel to the soil surface.*
4. *Remove large clumps of soil and air-dry slide.*
5. *With a small stream of water remove soil on undisturbed side until only a small film remains.*
6. *Clean undisturbed side with a damp cloth until all soil is removed.*
7. *Fix the slide by air drying and heating over low flame.*
8. *Now, place slide over boiling water bath and flood it for six to ten minutes with phenolic rose bengal by dropping rose bengal solution on slide as it drys.*

9. After six to ten minutes wash slide gently with water to remove excess stain.

10. Let the slide air dry.

11. Examine the slide microscopically.

    A. 10 X & 43 X to view fungi, plant rootlets, encysted nematodes and other larger microbes. Then remove any large grit and ...

    B. Use oil immersion to examine bacteria.

HAVE YOU MADE ALL THE KRITTER SHEETS OF WHAT YOU HAVE SEEN???!!!

EM-1 BACTERIAL ECOBIOLOGY
END OF MODULE TEST

MATCHING

1. _____Perfil'ev & Gabe
2. _____Vernadskii-Vinogradskii-Waksman
3. _____Neumann
4. _____Rossi-Riccardo-Kholodny
5. _____Beerstecher-Rogoff
6. _____Stotzky
7. _____Schloesing-Muntz
8. _____Beijerinck
9. _____Pasteur-Koch
10. _____Heraclitus

A. Geomicrobiology as a separate field of micro
B. clay minerals & microbial ecology
C. soil nitrification
D. found that carbon monoxide was oxidized to carbon dioxide by what he called Bacillus oligocarbophilus
E. implication of bacteria as the causative agents of specific diseases
F. surface features of the earth are not fixed and static
G. capillary microscopic method of soil microbe estimation, the 'microbial-landscape' method
H. first attempt to study bottom sediments with the submerged-slide technique
I. studied soil microbiocenoses using buried slides (1927, 30)
J. petroleum & coal microbiology

TECHNICAL TERMS: MATCHING

1. _____ Metallogenium, Gaulococcus
2. _____ diagenesis
3. _____ Cryptobium symbioticum
4. _____ gangue
5. _____ syngenetic
6. _____ Chlamydobacteriales
7. _____ Thiobacillus thiopans
8. _____ authigenic
9. _____ hydrotroilite
10. _____ rhodochrosite

A. are formed simultaneously with the host rock
B. sheathed bacteria
C. tolerates high salt, low Eh, and ppts. sulfur from H_2S
D. manganese carbonate
E. concentrate Mn & Fe in mud
F. amorphous, hydrated black iron sulfide of colloido-biologic origin
G. the transformation of sediments to rock material under modest heat, pressure and chemical cementation
H. the economically unimportant ore-bearing rock portion of a mined ore
I. independently formed without influence of surrounding environment
J. the peculiar symbiotic microbe mistakenly thought to be 'excreta' of the iron bacterium Gallionella

EM-1 BACTERIAL ECOBIOLOGY
END OF MODULE TEST (cont.)

DEFINE THESE TECHNICAL TERMS:

1. hypertonic=

2. alkalinophile (alkaloduric)=

3. redox potential=

4. aerotactic=

5. periphyte=

6. benthonic=

7. gnotobiosis=

8. fermentation=

9. L-phase variant=

10. pleomorphic=

TRUE-FALSE

1. __________ Heterotrophic bacteria and fungi use metal chelating agents as a source of C, N or energy.

2. __________ Sulfur in coal cannot be removed using Thiobacillus ferrooxidans because coal is too acid.

---

3. __________ Kendrick found that thirty-one species of fungi in a 'copper' swamp in Canada were dying from copper toxicity.

4. __________ Some Cyanophyceae, Chrysophyceae, Volvocales, and other algae precipitate iron and manganese by enzyme action.

5. __________ Proof of iron oxidation by Gallionella rests in the observation of growth in the absence of organic carbon.

6. __________ Clay mineral composition plays a leading role in determining microbial population levels.

7. __________ Gas vesicles of some purple and green bacteria are enclosed by membranes which are not cytoplasmic.

8. __________ An organism does not change its basic shape even as it ages.

9. __________ Aberrant cells are often called involution forms.

10. __________ The specific gravity of bacteria is about 1.07.

11. __________ A good general figure to know is that 10^{12} organisms weigh about one gram.

12. __________ A slime layer around a bacterial cell which is related to and organized around the cell wall is called a pili.

13. __________ Fimbriae are important to the slow moving bacteria for locomotion.

14. __________ A bacteria with one flagella is termed lophotrichous.

15. __________ Flageallatropic phages are known which attack *Escherichia coli* and *Bacillus subtilis*.

16. __________ The murein sacculus is composed of N-acetylmuramic acid and N-acetylblucosamine.

17. __________ Plasmolysis is almost always lethal.

18. __________ Cytoplasmic inclusions are nonprotoplasmic in nature.

19. __________ *Caulobacter* are stalked bacteria.

20. __________ Ethane-oxidizing bacteria are not found where soil has been contaminated by petroleum products.

EM-2 VIRUSES

PURPOSE:

To aid the student in developing an understanding of viruses.

MATERIALS:

Andrews, C.H. *Viruses of Vertebrates.* Williams & Wilkins.

Burret, F. M. and Stanley, W. M. *The Viruses (3 vols.)* Academic Press. (reference)

Cairns, J., Stent, G. S. and Watson, J. D. *Phage and the Origins of Molecular Biology*. Cold Spr. Hbr. Lab.

Douglas, J. *Bacteriophages.* Chapman & Hall.

Fenner, F. et. al. *The Biology of Animal Viruses.* Academic Press.

Fraenkel-Conrat, H. *Design and Function at the Threshold of Life: The Viruses.* Academic Press.

Fraenkel-Conrat, H. *The Chemistry and Biology of Viruses.* Academic Press.

Luria, S. E. and Durrell, J. E. *General Virology.* Wiley & Sons, Inc.

Kennedy, D. (ed) *The Living Cells.* Rdgs. from Scientific American. W. H. Freeman.

Sanders, F. K. *The Growth of Viruses.* Oxford Biology Reader #64. Oxford Press.

Stent, G. S. *Molecular Biology of Bacterial Viruses.* W. H. Freeman.

Stevenson, G. B. *The Biology of Fungi, Bacteria, and Viruses.* American Elseview.

Weistrich & Lechtman. *Microbiology & Human Disease.* Glencoe Press.

OBJECTIVES: To enable the student to:

1. Recognize the major parts of a virus.
2. Explain viral behavior.
3. Understand viral classification.
4. Recognize viral problems in the environment.

DATE STARTED: ______________________

EM-2 VIRUSES INSTRUCTION AND CHECK OFF SHEET

Although most of us equate viruses with the common cold the first work on viruses involved plants and cattle. In 1898 and 1899 studies of foot-and-mouth disease and the mosaic disease of tobacco showed that the casual agent was smaller than the usual bacteria and unlike bacteria would not replicate on plates (in vitro), but rather only in living tissue (in vivo). On tobacco the disease is manifested first by a bleaching of the chlorophyll and later by death of whole leaves or even the whole plant. As early as 1887 Adolf Mayer had shown that the disease was contagious. People who smoke can carry the disease to peppers, tomatoes, eggplants, petunias or any other Solanaceous plant by expressing sap from infected tobacco into fingers or into the air. Beijernick,the famous Dutch microbiologist, tried in vain to plate out the virus. He found that even when filtered through porcelain the virulent agent passed through and could still cause mosaic. The first virus to be completely purified was tobacco mosaic when in 1935 Stanly crystallized out TMV-firus needle-like crystals.

PACKET #1

Read Stevenson, The Biology of Fungi, Bacteria, & Viruses, pgs. 20-26 and Wistreich & Lechtman, Microbiology & Human Disease, pgs. 36-55; 156-166, 228-241, 530-543, 609-615, and 637-644. After reading materials utilize programmed review for this packet.

KRITTER SHEETS: __________________
VIRAL STRUCTURES: ________________
TISSUE CULTURE TECH. SHEET: ________

VIRAL CLASSIFICATION: __________________
REVIEW QUESTIONS: ______________________
ENUMERATION TECH SHEET: ________________
DATE COMPLETED: ________________________
INSTRUCTOR SIGNATURE: __________________

PACKET #2

Read Sanders, The Growth of Viruses, Oxford Biology Reader. Utilize the self-correcting quiz. Hand in to instructor when completed for credit.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #3

Read Douglas, Bacteriophages, pgs. 1-64. Utilize self-correcting quiz. Make up technique sheet on plaguing, use of absorptiometer & nephelometer. Hand in materials to instructor for credit.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #4

Complete Douglas, pgs. 65-128. Take self-correcting quiz and hand in to instructor for credit.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #5

Submit kritter sheets on techniques and new creatures: B dellovibrio, Streptococcus lactis, Staphylococcus aureus, Escherichia coli, Neurospora (fungi), Coliphage TZ, Bacillus subtilis, Corynebacterium diphtheriae, Bacillus megaterium, Pseudomonas pyocyanea, Salmonella typhimurium. Hand in to instructor for credit.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ________________

END OF MODULE TEST: ______________ DATE MODULE COMPLETED: ________________

EM-2 VIRUSES
PACKET #1 PROGRAMMED REVIEW

PART I - Stevenson

1. Because of the small size of viruses they pass through filters (such as Millipore) which will retain ________________. Filters ____________ available for retaining virus. A virus particle is called a ________________. The core is of ___________ acid; the protective coat of protein is called a _________. A capsid is composed of identical sub-units called ______________. NOTE: Begin construction of kritter-sheets on influenza virus, pox viruses, vaccinia virus, bacteriophage....these sheets are required in Packet #5 where all viral kritter sheets are inspected. Add to the sheets as you read this and other packets.	
2. The first virus to be isolated in the pure state is _____________ _____________. NOTE: TMV attacks any Solanaceous plant. The nucleic active portion of this virus is _______________.	1. bacteria are virion nucleic capsid capsomers
3. Variegation of leaves of plants is often caused by a ____________. Some viruses are used to control ______________. Viruses which attack bacteria are called _______________. NOTE: Herpes group for kritter sheet. Antibiotics and many chemotherapeutic substances _____________ effect upon viruses. Hydrogen peroxide and hypochlorites are ______________ agents and do kill virus.	2. tobacco mosaic (TMV) RNA
4. The initial phase of viral attack is the ______________ phase. Then the virus replicates and often results in _______________ of the host cell. Sometimes the virus remain in low concentration through several generations. It is then said to be a ___________________ ___________. Those viruses which remain a reservoir of disease continuously are ___________ _________________.	3. virus insects bacteriophages have no oxidizing
	4. eclipse lysis temperate phage latent viruses

5. When viruses multiply within a host's cells the large distinctive structures which remain within are called ______________ bodies. A substance which is not antigenic often diffuses from infected cells to given cells nearby a degree of immunity. This is called ______________. Phages can be used to ________________ a virus.	
6. Higher animals defend themselves against both bacteria and viruses by producing ______________ ________________. The antibodies react with the viral ______________ preventing it from multiplying and allowing ______________ to devour the invader. The reaction of antigens and antibodies to produce a visible precipitation or an ______________ of cells makes porssible the study of ________________. The most modern extension of serology is called ______________-________________ ____________________.	5. inclusion interferon type
	6. serum antibodies antigen phagocytes agglutinatipn serology immuno-fluorescent agglutination
PART II - Wistreich & Lechtman pgs. 36-55. Complete the review questions on page 56 and submit to instructor for discussion. If you have completed modules on algae, fungi, slime molds, etc., do you have kritter sheets on the animal viruses, bacterial viruses, and plant viruses as you encountered them? NOTE that even blue-green algae catch virus. If you have not started the other modules start kritter sheets on these viruses and the phages that attack them.	
PART III - Wistreich & Lechtman pgs. 156-166. Produce a cover sheet on viruses to include viral structures seen as you continue through this module. Include Figure 9-1. NOTE: Newcastle's Disease of Chickens. Reproduce the classification of viruses on page 165 for the kritter notebook. Show these pages to your instructor for check off.	

PART IV. Wistreich & Lechtman pgs. 228-241

1. An egg which has been fertilized by a rooster developed partially in a hen and in an incubator is called an ____________ egg. The advantages of using eggs are five in number. List them.	
2. The common bacterial disease of chickens is Salmonella ____________. NDV is ____________ ____________ ____________. Psitlacosis is caused by ____________. Fever blisters are caused by ____________ ____________. Small pox is caused by ____________. A viral venereal disease is Lymphogranuloma ____________. Do you have kritter sheets on these?	1. embryonated -readily available in large quantities -easy to grow and handle -egg provides constant environment -embryo unable to produce antibodies -genetics controlled and constant
3. Viruses must be grown in living ____________ ____________. NOTE: Prepare a technique sheet on the general requirements for tissue culture. The descendants of a single cell utilizing tissue cell culture are known as ____________. Tissue fragments taken from a clone line are called ____________. Plaquing was first introduced by ____________ in 1952. Living cells are stained with ____________ ____________. A PFU is a ____________ ____________ ____________.	2. pullorum Newcastle Disease virus Chlamydia Herpes hominus Variola venerum
	3. tissue culture clones explants Dulbecco neutral red trypan blue plaque forming unit
4. Place the information from Table 13-3 onto the appropriate bacterial kritter sheets. Prepare a technique sheet for phage enumeration. This will be useful in packet #2 also.	

PART V Wistreich & Lechtman pgs. 530-543; 609-615, 637-644.

This reading involves the detailed description of the important clinical viruses. Rearrange this material onto kritter sheets. You should now have over twenty sheets as a minimum.

EM-2 VIRUSES
PACKET #2 - SELF-CORRECTING QUIZ

1. What diseases are caused by viruses? List five.

2. Viruses have two phases to their lives; the first, the ______________ phase involves parasitism and allows them to replicate while the second stage, the ______________ phase leaves them open to the alien environment.

3. Viruses all contain nucleic acids, either __________ or _____________ but never both.

4. The 'shell' or coat of a virus is not continuous but is composed of _______________ which are discrete units. The nucleic acid core is surrounded by a _________________. Some viruses have even another coat, the _______________.

5. What terms are used to describe viral shapes?

6. Viral coats and the complex 'tails' are for two basic purposes. What are they?

7. The Hershey-Chase experiment proved that:

8. The vital clue to understanding of nucleic acid duplication was supplied by _______________________ and _________________________.

9. Some viruses are invaginated by the host and the viral cores are released during phagocytosis in a process called _______________________________.

10. The internal following penetration of a host cell by virus _______________ viral cells can be detected is the ____________________ phase.

11. Luria stated that infection by viruses exemplifies ___________________ at a ___________________ level.

EM-2 VIRUSES
PACKET #3 - SELF-QUIZ

MATCHING:

1. _____*lysis*
2. _____*filamentous*
3. _____*temperate*
4. _____*lytic*
5. _____*plaque*
6. _____*absorptiometer*
7. _____*B dello-vibrio*
8. _____*calcium*
9. _____*nephelometer*
10. _____*Versene*

A. measures turbidity of broth solution in the amount of light deflected sideways by cells.
B. the form of phage which leaks slowly out of the host bacterium without killing it.
C. a bacterium which acts like a phage. It parasitizes other bacteria.
D. the dissolution of the bacterial cell.
E. promotes absorption of bacteriophage.
F. ethylene-diamine-tetraacetic acid, EDTA
G. phages which integrate into the host so well as to avoid detection. Lyse only with special treatment.
H. the virulent form of bacteriophage which causes the cell to burst and release lysozyme.
I. measures turbidity as the impedance offered to light passing through the suspension.
J. the 'cleared' area on a bacterial lawn caused by lysis of the host cells.

PLAQUE TECHNIQUE: Describe the plaque technique for estimating phage titre.

Draw and describe parts of a typical Coliphage Virion.

EM-2 VIRUSES
PACKET #4 - SELF-QUIZ

MATCHING

1. _____*F. W. Twort*
2. _____*F. d'Herelle*
3. _____*Hershey-Chase*
4. _____*R. G. Milne*
5. _____*S. E. Luria*
6. _____*A. D. Hershey*
7. _____*Benzer*
8. _____*A. Campbell*
9. _____*Avery*
10. _____*Lederbergs, Zinder & Lively*

A. *Lambda biology coliphage lambda and its relatives the lamboids*
B. *bacterial transformation*
C. *shortly after phage infection it is possible to remove most of the phage protein, but little of the nucleic acid.*
D. *first to suggest the minimum distance between two genetic sites still separable by recombination*
E. *Bacillus subtilis attacked by SP 50-theta phages "ghost phages" (Rothamsted Laboratory)*
F. *discovered what he called 'transmissible lysis' and suggested that the Micrococcus might have been attached by a virus (1915)*
G. *studied the overall strategy of copying . . . discovered the modus operandi of a phage . . . exponential*
H. *lambda and lambda mutants genetic mapping*
I. *using Salmonella typhimurium they discovered bacterial transduction*
J. *rediscovered 'bacteria-eating' viruses which he called bacteriophage (1917)*

1. _____*colicin*
2. _____*bacteriocin*
3. _____*phenol & surface active agents*
4. _____*bacteriocinogen*
5. _____*lysogeny*
6. _____*mitomycin C*
7. _____*prophage*
8. _____*suicide technique*
9. _____*antisera*
10. _____*exogenote*

A. *the DNA genetic element which allows a bacteria to produce its characteristic bacteriocin*
B. *behaves so much like a gene that indeed it may be so well integrated into the cell chromosome as to be a gene*
C. *a fragment of bacterial donor chromosome used in transduction*
D. *the collective group of substances which are produced by one bacteria to specifically ward off another bacteria of the same species*
E. *utilizes labelled phosphorus or tritiated thymidine*
F. *destroy both bacteria and phage by stripping off protective protein coats*
G. *an antibiotic which incidentally induces lysis of normally lysogenic cells*
H. *a protein produced by one strain of E. coli and lethal to another strain*
I. *produced by inoculating rabbits and subsequently removing blood and separating out a yellow serum*
J. *a phage-host relationship in which host cell lives and multiplies normally and phage does not cause rupture of cell unless 'conditions' change*

EM-2 VIRUSES
END OF MODULE TEST

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1. Draw a typical Coliphage Virion. Label all parts.

2. Using drawings and a short written description describe the mechanics of infection by a virus.

3. Describe the lysogeny process.

4. Enumerate the steps in making a plaque essay.

5. How may viruses aid bacteria in combating antibiotics.

6. Describe both old and new viral classification schemes.

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7. *What is the nature of 'mosaic'?*

8. *What are rickettsia? Mycoplasmas? How are they related to viruses?*

9. *How are phages utilized in bacterial identification?*

10. *Are viruses a problem in sewage treatment? If so, how are they controlled?*

HAND IN TO INSTRUCTOR FOR HIS EVALUATION.

NAME: ______________________________

DATE: ______________________________

EM-3 NEMATODES

PURPOSE:

to introduce the student to the roundworms, and the Nematodes; both the relatively few which are troublesome and the majority which are normal fauna of soils, composts, and aquatic environment.

MATERIALS:

1. Nematode Kit No. 34 from Lab Aids, Inc.
   Lab-Aids Inc., Bohemia, New York, 11716.

2. Texts and References

Brand, R. von. Chemical Physiology of Endoparasitic Animals. Academic Press.

Chitwood, B. G. and Chitwood, M. B. An Introduction to Nematology. Monumental Printing Co.

Cobb, N. A. Nematodes and Their Relationship. U.S.D.A. Yearbook for 1914.

Crofton, H. D. Nematodes. Hutchinson University Library, Hutchinson & Co., Ltd.

Doncaster, C. C. Nematode Feeding Mechanisms and Observations on Rhabditis & Pelodera. Nematologica, 8, 313-20.

Dropkin, V. H. The Relations Between Nematodes and Plants. Exp. Parasit.4: 282-322.

Fairbairn, D. The Biochemistry of Ascaris. Exp. Parasit. 6: 491-554.

Fenwick, D. W. Methods for the Recovery and Counting of Cysts of *Heterodera schachtii* from Soil. J. Helminthology 18(4):155-172.

Goodey, T. Plant Parasitic Nematodes and the Diseases they Cause. Methuen Press.

Goodey, T. Soil and Freshwater Nematodes, 2nd ed. Methuen.

Gray, J. Undulatory Propulsion. Quart. J. Micro. Sci. 94, 551-78.

Hyman, L. H. The Invertebrates, Vol. III. McGraw-Hill.

Jones, F. G. W. Ecological Relationships of Nematodes. In Plant Pathology: Problems and Progress 1908-1958. University Wisconsin Press.

LaPage, G. Nematodes Parasitic in Animals. Methuen & Co., Ltd.

MATERIALS: (cont'd)

Lee, D. L. The Physiology of Nematodes. Oliver & Boyd.

Mai, W. F. Pictorial Key to Genera of Plant-Parasitic Nematodes. Cornell University Press.

Nobel, E. R. & Nobel, G. A. Parasitology: The Biology of Animal Parasites. Lea & Febiger.

Overgaard, N. C. Studies on Soil Microfauna II: The Soil Inhabiting Nematodes. Natura Jutlandica, 2.

Prosser, C. L. and Brown, F. A. Comparative Animal Physiology, 2nd ed. W. B. Saunders, Co.

Sassner, J. N. and Jenkins, W. R. (ed.) Nematology: Fundamentals and Recent Advances with Emphasis on Plant Parasitic and Soil Forms. University of North Carolina Press.

Steiner, G. Plant Nematodes the Grower Should Know. S. S. S. Fla. Proc. 4 (B).

Tracey, M. V. Cellulase and Chitinase in Plant Nematodes. Nematologica 3:179-83.

Wallace, H. R. The Biology of Plant Parasitic Nematodes. Arnold Ltd.

Winslow, R. D. A New Method for the Production and Recovery of Cysts of Root Eelworms (Heterodera spp.) for use in Bio-Essay. J. of Helminthology, 24(1/2):49-54.

OBJECTIVES: To enable the student to:

1. Recognize the more important human, animal and plant nematodes.

2. Compare nematode anatomy.

3. Capture nematodes from the environment, mount them, stain them and store them for future use.

4. Measure nematode populations.

5. Classify nematodes and relate them to their ecological situation.

6. Become familiar with the major references and the literature of nematology.

EM-3 NEMATODES
AN INTRODUCTION

> ". . . If all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes, and oceans represented by a film of nematodes." (Cobb, 1914)

All nematodes at some stage of their life are elongate worms, the body shape ranging from fusiform to nearly cylindrical with rounded ends. Most nematodes are of this shape throughout their lives, but adult females of certain important plant parasites develop bodies which are pear, lemon, or kidney-shaped, or otherwise enlarged. Soil and plant-parasitic nematodes range in length from a minimum of about 0.25mm to a maximum of about 10 mm. The great majority of species are 2 mm long. All told, there are probably 10,000 different species of terrestial nematodes.

In their feeding habits, nematodes are saprophytic, predaceous or plant parasitic. The saprophytes and predators feed on decaying organic matter and on the smaller forms of soil life, such as the bacteria, protozoa and small nematodes. They complete their life cycles in or near decomposing organic matter. Plant-parasitic nematodes are found in rhizosphere soil, in plant roots, and in the foliage and seeds of plants. Mostly, however, they are limited to the rhizospheres and roots of their hosts. They are attracted to these areas by chemical stimuli, that is, by water-soluble matabolic products secreted by the host plant. The larvae of parasitic species may move randomly in the soil and persist therein for several weeks, but if they fail to migrate to a sphere of chemical stimuli and thence to a host rootlet, they will eventually die without completing their life cycle.

Included in this module are Crofton's paperback on Nematodes, several articles from the literature on nematodes, a classification handout and a kit which will allow the student to capture these interesting creatures and to view them under a microscope.

ZM-3 NEMATODES INSTRUCTION AND CHECK OFF SHEET

PACKET #1

Read eleven page introduction from Nematode Kit #34 (Lab-Aids Inc.) and then complete the self-quiz. Start F.I.D. sheets on Ascaris lumbricoides, Trichinella spiralis, and Necator americanus. Utilize classification handout. Show sheets to instructor and request answer sheet for correction of self-quiz.

DATE COMPLETED: ____________________
INSTRUCTOR INITIALS: ________________

PACKET #2 - MORPHOLOGY OF NEMATODES

Read chapters 1 -9 in Crofton's Nematodes. Complete the programmed review and self-quiz. Utilize prepared slides of typical nematodes.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ________________

PACKET #3 - CAPTURING NEMATODES

Utilize Film strip- cassette Lab-Aid #34 and after reviewing use Nematods Kit #34 and capture nematodes. Produce a permanent slide of your nematodes and label with genus (if possible), date and habitat. Submit slide and kritter sheet to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR INITIALS: ________________

PACKET #4

Read Fenwick and Winslow's articles on Nematodes and produce Data Storage cards on methods described. Technique sheets should be prepared for your F.I.D. notebook which includes basic method of Kit and added suggestions from Crofton, Fenwick and Winslow. Submit these Technique sheets and the Data Storage cards to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR INITIALS: ________________

PACKET #5 - ECOLOGY OF NEMATODES

Complete reading Crofton's NEMATODES - chapters 10-15. Reproduce in entirety AN OUTLINE CLASSIFICATION OF THE NEMATODE for the F.I.D. notebook. Note on this sheet the Phasmidia v.s. Asphasmidia problem and use the asterisk as suggested on your outline. Place your notes on Nematodes in this F.I.D. for use on TESTS. REQUEST PROGRAMMED REVIEW.

DATE COMPLETED: ____________________
INSTRUCTOR INITIAL: ________________

REQUEST END OF MODULE TEST: ____________________

COVERSHEET TO NEMATODES IN KRITTER BOOK: ____________________

CLASSIFICATION OF NEMATODES: ____________________

DATA STORAGE CARDS: ____________________

KRITTER PAGES ON NEMATODES: ____________________

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ____________________

EM-3 NEMATODES
CLASSIFICATION OF NEMATODES

SUPER PHYLUM: ASCHELMINTHES (all Phyla which have body cavities) as suggested by Hyman[1].

PHYLUM:	ROTIFERS	PHYLUM:	GASTROTRICHA
PHYLUM:	KINORHYNCHA	PHYLUM:	NEMATOMORPHA
PHYLUM:	NEMATODA[2]		

CLASS	ORDER	SUBORDER	SUPERFAMILY
Secernentea (Phasmidia)			
	Rhabditida	Rhabditina	Rhabdiasoidea
			Rhabditoidea
	Strongylida	Strongylina	Syngamoidea
			Ancylostomatoidea
			Strongyloidea
		Trichostrongylina	Trichostrongyloidea
			Heligmosomatoidea
		Metastrongylina	Metastrongyloidea
			Protostrongyloidea
			Pseudalioidea
	Ascarida	Ascaridina	Ascaridoidea
			Heterocheiloidea
		Heterakina	Heterakoidea
			Subuluroidea
			Aspidoderoidea
			Cosmocercoidea
		Oxyurina	Oxyuroidea
			Syphacioidea
	Spirurida	Spirurina	Spiruroidea
			Thelazioidea
			Gnathostomatoidea
			Acuarioidea
			Physalopteroidea
		Camallanina	Camallanoidea
			Dracunculoidea

EM-3 NEMATODES

CLASSIFICATION OF NEMATODES (cont.)

CLASS	ORDER	SUBORDER	SUPERFAMILY
		Filariina	Filarioidea Onchocercoidea
	Tylenchida		
Adenophorea (Asphasmidia)			
	Trichinellida	Trichinellina	Trichinelloidea
	Diotophymatide	Dioctophymatina	Dioctophymatoidea Eustongyloidea

---

[1] Hyman, L. H. 1951. The Invertebrates: Acanthocephala, Aschelminthes, and Ectoprocta, Vol. III. McGaw-Hill, N. Y.

[2] Only orders and superfamilies containing parasitic representatives are included here.

AN OUTLINE OF NEMATODES

EM-3 NEMATODES
PACKET #1 - SELF-QUIZ

---

1. Is it true that most nematodes are parasitic? Why?

2. Nematodes are rare and hard to find in healthy environments. Is this true? Why?

3. Draw the general morphologyof a male nematode and label: papilla, pharynx, nerve ring, excretory pore, ecelomocyte, pseudocoelom, testis, sperm, intestine, vas diferens, genital papilla, spicule, cloaca bursa and supporting ray. Use a kritter sheet for later insertion in your kritter book.

4. While nematodes were once placed in a separate phylum the ____________ ____________________; they are now placed within the ______________________.

5. Can you store live nematodes?

6. What mixture is used to make permanent slides of nematodes?

7. Draw pictures and describe live, recently dead, and long dead nematodes. Why is this important to environmentalists?

8. How do you TICKLE nematodes?

9. What is the 'turgor' test?

10. What is the best tool for playing with nematodes?

EM-3 NEMATODES
PACKET #2 - PROGRAMMED REVIEW MORPHOLOGY OF NEMATODES

1. One of the first written records about nematodes (about 1500 B.C.) is contained in ________ ________ in which ________________ ________________ and ____________________ ____________________ are mentioned. (PLACE ON F.I.D. SHEETS IF YOU HAVE NOT ALREADY) The Jews called them ______________ ____________. Is Agatharchides on a 3" x 5" card? Which Greek philosophers mention nematodes? _________ and ________________.	
2. Enterobius vermicularis is the ______________ worm. The casual agent of hookworm is _______________ ____________________. Meat inspection was started by the work of Virchow, Herbst and ________________ in about 1860.	1. Papyrus Ebers Ascaris lumbricoides Dranunculus medinensis fiery serpents Hippocrates Aristotle
3. On kritter sheet for horse place nematode of horses __________________ ______________. On kritter sheet for dog place kidney worm found by ______________ in the 1600's. On kritter sheet for pig place information on Trichinella __________________.	2. pin Ancylostoma duodenale Leukart
4. Plant nematology began with _______________ who discovered the 'wheat blight' nematode ____________ ____________. (Place on wheat kritter sheet). Note that 'wheat blight' is also caused by a fungus, which you will read about in Fungi module and Plant Pathology module.	3. Oxyuris equi Caesalpinus spiralis
5. First anatomical study of nematodes was written by Butschli who discovered ____________ bodies while studying division of ovum of Ascaris lumbricoides. Van Beneden in 1883 discovered the _______________ of off-spring are derived equally from ovum and ____________________.	4. Needham Anguina tritiei
	5. polar chromosomes sperm

6. The standard text to which all nematologists refer is INTRODUCTION TO NEMATOLOGY by ____________________ NOTE BIBLIOGRAPHY.... PLACE IN DATA STORAGE ALL THOSE BASIC REFERENCES. NOTE THE DETAIL IN FIG. 1. This was accomplished under a microscope. Your drawings should be equally detailed.	
7. Shorter cylindrical tapered nematodes are called ______________. While those with a very long tube are called ____________________.	6. Chitwood
8. Figure 2 should be reproduced on kritter sheet for inclusion in kritter notebook.	7. fusiform filiform
9. The pseudocoelomic fluid of nematodes is maintained at very high ___________ pressure. The cuticle is so constructed that changes in pressure cause change in ______________. This characteristic is termed _______________. The reproductive system operates by ____________. Nematodes are considered to be the most advanced pre- _________________. Locomotion and feeding in ____________ are independent but in nematodes they are interdependent. This is more _____________ but requires that medium for locomotion must be related to _______________ supply.	8. place in nematode section
10. In nematodes the greater the worm diameter the ______________ is ___________ thickness. The cuticle has four basic layers: ________________, _____________, _____________, and _______________. The upper three are visible with an ordinary light ________________, but the lower may be missing or only visible using _________________. The cuticle is a ___________-living structure produced by the ________________.	9. turgor length anisometry peristalsis -coclomates coelomates efficient food
	10. greater cuticle cortex matric fiber basic membrane microscope electronmicroscopy non hypodermic

EM-3 NEMATODES
PACKET #2 - PROGRAMMED REVIEW MORPHOLOGY OF NEMATODES (cont.)

11. The ______________ is basically a cellular layer which secretes the ____________ and is linked to the ____________ muscle cells by ______________. In all all nematodes there are two main projections into the ____________ cavity. Two lateral ______________ and from these two ______________ projections (dorsal and ventral) divide the cross-section of a nematode into ________________.	
12. The hypodermis is the place of storage of metabolic ______________ and ____________. Gland cells are associated with ______________ organs. In some forms gland cells at the tail ____________ material which glues them to the ______________. Recall that rotifers have ______________ and are closely related to nematodes.	11. hypodermis cuticle somatic fibers body chords subsidiary quadrants
13. Muscle cells are arranged ____________. The number of muscle cells is important in classification. If only 2-5 half the nematode is described as ________________, but if there are many muscles it is ___________________.	12. fat glycogen sensory secrete substratum spinnerets
14. Nerves of nematodes are like muscles, ___________. They connect at the anterior end to the ____________ and posteriorly to the ________________. The main body of the nerve cords is called the ______________.	13. longitudinally meromyarian polymyarian
15. Nematodes have three kinds of receptors ___________, ___________ and ______________ receptors. All nematodes have diagnostically useful ____________ which have an external opening that is used to divide nematodes into the ___________ and the ____________.	14. longitudinal pharynx anus ganglia
	15. tacto- chemo- light- amphids Phasmidia Aphasmidia

16. In the tail region of many nematodes are glandulo-sensory structures called _______________. Some nematodes have 'ocelli' which are light-sensitive and act as ____________________. Nerve cords are connected by ___________ to pharynx and lumbar regions. Modern work on nematode nervous systems is ____________ and has not shown much not accomplished by ___________ in 1853.	
17. Nematodes move essentially in a ___________, their motions being random if in open water rather than in a ___________. The larger the nematode the more ____________ must be the fluid in which they live. Control of muscle activity in nematodes is __________________, that is, muscles are inherently active but are ___________ by the nervous system. Muscles not only are contratile elements but are proprio-receptors as well.	16. phasmids eyes comissures topological Meissner
18. One of the interesting and poorly understood systems in nematodes concerns their excretory system. In some nematodes there are _________ structures which can be called excretory. In some there are lateral _____________ cords which are referred to as excretory. Evidently a few nematodes have a system for _____________ removal, but most nematodes simply use the fluid in the ______________ as a means of ridding themselves of nitrogenous waste. The enzymes concerned with ______________, the destruction of unused organic chemicals, are concentrated and not in the lateral organs, but rather in the ______________ cells. Most of the large quantity of protein produced by female nematodes goes into ______________ production. Other large portions of nitrogeneous waste goes into sluffed off cuticle. The lateral canal system or _____________ system is involved primarily in _________________ regulation.	17. plane film viscous myogenic controlled
19. Notice that nematodes can be classified to a great degree by noting their mouth construction. Usually the mouth is ___________ and surrounded by _______________; often there are ____________ pairs of these lips. Some plant parasitic forms possess spears of _____________ which aid in penetrating cuticle walls. Note Figure 10 and how distinctive the forms are. Mouths and pharynx must be carefully studied and drawn during analysis of nematodes.	18. no hypodermal waste gut catabolism gut egg renette osmotic
	19. terminal lips three (3) stylets

20. Note that plant parasitic nematodes produce 'saliva' which contains enzymes which break down plant materials. All enzyms end in the suffix- _________. Cellulose breaks down ____________; chitinase, ___________; pectinase, _____________; and amylase, ______________. Animal parisitic nematodes possess enzymes like protease which breakdown ______________; hyaluronidase which breaks down the structural polysaccharide in higher animals, ____________ acid; and lipases which breakdown ___________________.	
21. The pumping organ of the nematode is the ________________. The pharynx also acts as an_______ control. Viscosity of fluid food, size and number of ingested particles, and ____________ physiology of the individual nematode ________________ to produce a pumping system unmatched by other creatures on this earth. The intestines of nematodes are lined with _____________-villi. The movements seen in nematodes when viewed under the microscope are caused by the ______________ of the body wall.	*20. -ase cellulose chitin pectin starch proteins hyaluronic fats*
22. Nematodes live in environments rich in _______________ acids, and __________________. They feed extravagantly and ___________________. Their intestine walls are ____________________ and highly efficient for ____________________. At the hind end of the nematode is a 'flap-valve' called a _______________.	*21. pharynx osmotic feeding habits combine micro muscles*
23. There are both male and female nematodes. They are therefore ___________. Some are _____________ and others have no sex and reproduce by ___________. Males are usually _________ in size and have special _____________ to aid in copulation. Usually there are ________ males than females in a given population. Many nematodes which reproduce without sex in other environments or when subjected to change will revert to a ____________ cycle.	*22. amino sugars wastefully thin absorption sphincter*
	23. dioecious hermaphrodite parthenogenesis smaller structures less sexual

24. In the male the gonads are always continuous with their ____________. The female reproductive tract consists of a ___________, a single and usually short _________, a pair of __________, oviducts and _____________. Fertile eggs are soon covered by a ______________ wall. The eggs are often distinctive and rather easy to identify because they are often ____________. Many females eject eggs into the environment, usually partially or wholly embryonically developed using their ______________.	
25. The main parts of the male reproductive system are the ____________, the seminal _________, and the vas ______________. Observation of sexual parts of male or female and of copulatory ___________ makes possible final identification of nematode species.	24. ducts vulva vagina uteri ovaries protein ornamented ovijector
	25. testis vescicle diferens spicules

EM-3 THE NEMATODES

PACKET #5 - PROGRAMMED REVIEW - CROFTON'S NEMATODES - Chapters 10-15

1. The formation of a __________ animal from an egg is achieved by the single cell being divided to give first ___________ cells, then _________ cells, then ___________ cells, then __________ cells and so on. This process is termed _________. Cleavage in nematodes is ____________ and displays ______________ development. Interestingly the germ-cell line of cells in nematodes can be ______________ traced from one ____________ to the next. (You are not responsible for the details from pages 92 "The special features...." to page 97. Do read the last paragraph of Chapter 10).	
2. Metabolism: Nematodes are known to live in oxygenated environments called ________________ environments and in those muddy organic rich environments which are __________________. Some live in environments which alternate between being rich in ___________ and devoid of ______________. In all animals the main source of energy ______________ and the main stored form of energy is ________________. *NOTE:* On page 99 the Embden-Meyerhof sequence and the Krebs cycle are considered. If you have not completed the BIOCHEMISTRY MODULE you may seek aid from the instructor concerning this section. You are not quizzed in this packet for the details from pages 99-101.	1. metazoan 2 4 8 16 cleavage determinant mosaic continuously generation
3. Continue on page 102 "The difficulty of predicting..." Intestinal forms live in an ______________ environment. These forms utilize the ____________ process. Some forms live in an anaerobic environment but obtain oxygen from the blood of the __________________. Since blood is drawn from the victim and the oxygen utilized in production it is small wonder that the host suffers_______________.	2. aerobic anaerobic oxygen oxygen carbohydrate glycogen
4. Fats are stored in _____________ and ________ as an energy _________________.	3. anaerobic fermentative host anemia
	4. eggs larvae reserve

5. Despite the many life styles and histories of nematodes they have a simple basic developmental plan. Name the six stages.	
6. What occurs between stages?	5. a. egg b.-e. four larval or immature adult stages f. an adult reproductive stage
7. Note especially page 109 where parasites and saprophytes are compared. (A) A short generation time and ______________ egg production requires that there be several generations before ____________ size allows dramatic increase. This occurs when environmental conditions allow great __________. (B) A _____________ generation time and high rate of egg production occurs when suitable habitats are ________________.	6. moulting or "ecclysis"
8. The ability to resist high temperatures is called _____________. Nematodes can survive and ________________ and ____________ more than many other creatures. They can be stored in the ___________-____________ condition. The _________ of some nematodes not only survive cold or hot and extreme drying conditions, but in this dormant state can be blown by ____________ to new sites. Some nematodes survive in other animals until a suitable better host is reached. This intermediate host is termed a _____________ host.	7. low population constancy long scattered
9. FREE LIVING FORMS: Although nematodes are often classed as marine, freshwater, or terrestrial there really are no ________________ forms since all nematodes require at least a water _______________. All nematodes have a ___________ origin. Unfortunately but realistically ____________________ groupings of nematodes bear little relation to classification. Hyman has estimated there must be ____________ a million species of nematodes, but only _____________ species are known.	8. cryptobiosis freezing drying freeze-dried cysts wind transport
	9. terresterial film marine ecological half 9.000

10. Note Table 6 - Estimates of Nematode Species - (F.W. = fresh-water). Do you see how much work remains on these creatures? Where are marine species found? Between fresh and salt areas in the estuaries the __________-water forms abound. Hot-springs are often invaded by soil ______________.	
11. One well known fresh water form of nematode is Turbatrix aceti, the __________ ____________. The nematode so often encountered in sand filters in the water or sewer works is ___________ ________________. High oxygen tension is required for freshwater nematodes so that less of them are found in deep ______________. Heavy clay soils are ______________ in nematode population . The largest number are found in soil rich in ____________ and of open ______________. In most soil ______% of nematodes are found in the top six inches. Per acre there may be up to ______________ nematodes. ARE THE VINEGAR EEL AND FILTER-BED EEL in your kritter notebooks?	10. mainly on shelves or slopes, (less at deep sea); on algae or epiphytes; in polar and tropical seas.....but few are planktonic brackish nematodes
12. The most important reference on plant parasitic nematodes is by ________________. All texts in the SELECT BIBLIOGRAPHY, pg. 153, should be in DATA STORAGE. Nematodes cause what problems in plants? List them.	11. vinegar eel Panagrellus silusiae lakes low humus texture 90 10^{10}
13. List octoparisitic species. List endoparasitic species.	12. Wallace suck juices cause wounds galls distortions death allow other parasites to invade spread viruses
	13. produce 8½" x 11" page for kritter notebook.

EM-3 THE NEMATODES
PACKET #5 - PROGRAMMED REVIEW - CROFTON'S NEMATODES (cont.)

14. Produce kritter sheets as follows: A. Heterodera rostochiensis & H. Schachtil B. Meloidogyne hapla C. Pratylenchus peretrans D. Ditylenchus dipsaci E. Aphelenchoides ritzema-bosi F. Anguina tritici NOTE: IF YOU HAVE NOT ALREADY DONE SO THE HOSTS TO THE ABOVE SHOULD BE ON KRITTER SHEETS AND CROSS REFERENCED.	
15. List on the page with plant parasites (question #13) the animal parasites under INVERTEBRATE and VERTEBRATE parasites.	14. Hand in at end of this packet
16. Prepare kritter sheets on the following possibly encountered parisites. A. Mermis subnignicans, Hexamermis sp., & Mermithides (one sheet) B. Tylenchinema oscinellae C. Strongyloides papillosis D. Rhabdias bufus E. Haemonchus contortus F. Ancylostoma duodenate (assigned previously) G. Syngamus trachea H. Metastrongylus apri I. Enterobius vermicularis (assigned previously) J. Heterakis gallinae K. Ascaris lumbricoides (assigned previously) L. Tertrameres fissipina M. Dracunculus medinensis (assigned previously) N. Vucheria bancrofti (assigned previously) O. Trichinella spiralis (assigned previously) P. Dioctophyme renale	15. submit with classification schemes and kritter sheets

SUBMIT ALL SHEETS AND REQUEST END OF MODULE TEST.

EM-3 NEMATODES
END OF MODULE TEST

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1. Draw on a kritter sheet a hypothetical female nematode and label: buccal cavity, amphid, spermatheca, exretory gland, vagina, eggs, coelomocyte, rectal gland, dilator muscle and intestine.

2. What may a male nematode have that a female did not? (anatomically speaking).

3. Describe how to capture a nematode.

4. How are nematode slides produced?

5. According to their feeding habits plant parasitic nematodes are divided into two large groups. What are they and how are they distinguished?

6. Describe one of the animal parasitic nematodes using your kritter sheets and DATA STORAGE DECK.

7. Outline the life cycle of one of the nematodes parisitic on man.

8. Describe the body wall of a typical free-living nematode.

9. How are plant parasitic nematodes controlled?

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10. How are animal and/or human pathogenic nematodes controlled?

HAND IN TO YOUR INSTRUCTOR FOR HIS EVALUATION.

NAME: ________________________________

DATE: ________________________________

CLASS SECERNENTEA (PHASMIDIA)

I. ORDER RHABDITIDA (SUBORDER THABDITINA)

1. Superfamily Rhabdiasoidea

May be source of all parasitic roundworms.

Live in decaying flesh, dung, decomposing organic matter.

Members of this order possess head sense organs in the form of papillae, and the amphids are reduced to small pockets.

Representative Genus (Families yet undefined)

Strongylides stercoralis: Parasitic of mammals, chimpanzees, dogs, cats. WORLDWIDE: prefers warm climate.

2. Suprefamily Rhabditoidea

Found on or in many animals, primarily invertebrates, as well as on plants.

The worms have two esophageal bulbs.

Representative Genera (Families ill-defined)

Rhabditis coarctata and R. ocypodis of beetles and crabs.

Neoaplectana glaseri: a free-living nematode whose larvae helpfully attack Japanese beetles..... A BIOLOGICAL CONTROL!

II. ORDER STRONGYLIDA (SUBORDER STRONGYLINA)

1. Superfamily Strongyloidea

"Strongylos" means round or compact.

Strongyles are found in horses and other equids, elephants, rhinoceroses, rodents, swine and many other mammals.

Common equine strongyles are:

Strongylus equinus, S. edantatus and Triodontophorus sp.

2. Superfamily Syngamoidea

Represented by the 'gapeworm", Syngamus trachea which lives in the trachea of poultry; by the kidney worm of pigs,

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Stepanurus dentatus; by the nodular worms, *Oesophagostomum* dentatum of swine; *O. columbianum* of sheep and *O. renulosum* of sheep and goats.

3. Superfamily Ancyclostomatoidea

The Hookworms

Ancylostoma caninum in dogs.

A. tubaeforme in cats.

A. braziliense in all felines and man.

A. ceylonicum in man.

A. duodenale in man.

Uncinaria stenocephala in dogs, foxes, wolves and man.

Unicinaria lucasi of seals.

Necator americanus of dogs and man.

ORDER STRONGYLIDA (SUBORDER TRICHOSTRONGYLINA)

1. Superfamily Trichostrongyloidea

Represented by the wireworms or twisted stomach worms.

Haemonchus contortus, *Ostertagia ostertagi* and *Cooperia punctata* of ruminant animals.

The red worm of rats: *Nippostrongylus brasiliensis* (*muris*).

The ruminant worms, especially of wild ruminants like deer, moose and oxen: *Nematodirus spathiger* and *N. helvetianus*.

There are eight known species of *Trichostrongylus* which cause black scours of animals (including man).

The red stomach worm of swine is *Hyostrongylus rubidus*, a blood sucker.

The lungworm of large mammals, *Dictycaulus viviparus*; infects elk, bison, deer, pigs and moose.

2. Superfamily Heligmosomatoidea

Ill-defined as yet.

ORDER STRONGYLIDA (SUBORDER METASTRONGYLINA)

1. Superfamily Metastongyloidea

Represented by the thread-worms Metastrongylus elongatus, M. salmi and Choerostrongylus pudendotectus, which cycle via earthworms to swine carrying incidentally another viral disease....swine influenza.

Angiostrongylus cantonensis - the rat lungworm. It can infect man or animals which eat uncooked prawn, crabs or vegetables from soil infested with this devil.

2. Superfamily Protostrongyloidea

Represented by the filaroidean lungworms such as Protostrongylus rufescens of sheep and goats.

3. Superfamily Pseudolioidea

Ill-defined as yet.

III. ORDER ASCARIDA (SUBORDER ASCARIDINA)

1. Superfamily Ascaridoidea

Represented by the giant ascarid Ascaris lumbricoides...... WORLDWIDE.

Related to A. lumbricoides is A. suum of pigs and Ascaridia galli of domestic and wild birds.

Sometimes children contract the dog and cat roundworms Toxocara canis and Toxascaris leonina.

3. Superfamily Heterocheiloidea

Represented by the family Aniskidae whose larvae infect fish.... and if man eats uncooked herring,...he may contract anisakiasis (Herring-worm disease). Marine fish also are infected by species of Contracaecum.

ORDER ASCARIDA (SUBORDER HETERAKINA)

1. Superfamily Heterakoidea

Represented in this group are Histomonas meleagridis harboring Heterakis gallinae. The protozoan H. meleagridis are carried in the eggs of the nematode and cause blackhead disease of poultry, especially turkeys. This is why turkeys are grown on wire and one of the reasons why wild turkeys disappeared from New England.

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3. Superfamilies Subuluroidea, Aspidoderoidea and Cosmoceroidea have no known pathogens important to man.

ORDER ASCARIDA (SUBORDER OXYRINA)

1. Superfamily Oxyuroidea

All members of the Oxyuroids are parasitic, primarily of vertebrates and are commonly called pinworms.

Pharynogodon mamillatus, Eumeces algeriensis, and Thelandros bulbosus attack lizards.

Oxyuris equi is the horse pinworm.

2. Superfamily Syphacioidea

Syphacia muris and S. obvelata attack rats and mice, respectively and man by accident.

Enterobius vermicularis is the 'seatworm' of man.

IV. ORDER SPIRURIDA (SUBORDER SPIRURINA)

1. Superfamily Spiruroidea

Ruminant animals catch Gongylonema pulchrum, but man can also.

2. Superfamily Thelazioidea

The Oriental eyeworm Thalazia callipaeda and the Cakifornia eyeworm, T. californiensis attack vertebrates including man.

3. Superfamily Gnathostomatoidea

Normally parasitic of cats and some other mammals, but by accident, also man.

Gnathostoma spinigerum is most common.

Small crustacea like Cyclops are intermediates.

4. Superfamilies Acuatioidea and Physalopteroidea are non-parasitic.

ORDER SPIRURIDA (SUBORDER CAMALLANIA)

Of the two superfamilies only Dracunculoidea has parasites affecting man; the worst being Dracunculus medinensis, the Guinea worm. It's intermediate host is the Cyclops, but it grows to four feet in man, dogs, cats or other mammals before mating in connective tissue.

ORDER SPIRURIDE (SUBORDER FILARIINA)

1. Superfamily Filarioidea

A typical filial worm involves a blood-sucking insect. Adults are filarial but they produce microfilariae.

The duck parasite, Splendidofilaria fallisensis uses the blackfly as an intermediate host.

In tropical countries Wuchereria bancrofti causes the dread elephantiasis.

The genus Brugia has the species malayi which is pathogenic to humans and other mammals.

B. pahangi affects carnivores.

Both B. malayi and B. pahangi use mosquitos as vectors.

2. Superfamily Onchocercoidea

Permanent species in this group are Onchocerca volvulus, the causal agent of onchocerciasis.

Several species of Onchocera occur in gorillas, cows, deer, water buffalos, donkeys, camels and African antelopes.

The monkey serves as a host reservoir for the eye worm of Africa, the Loa loa. The worms migrate from lungs to perpetual tissue at night so as to be spread by the intermediate hosts, the horse or mango fly.

The hearworm, Dirofilaria immitis, so common now in New England, belongs to this superfamily. It is spread by a mosquito and can infect man on occasion.

V. ORDER TYLENCHIDA

At present this order is made up of three families.

Tylenchidae
Allantonematidae
Myenchidae

Typical of these is Tylenchinema oscinellae which parasitizes the frit fly Oscinella frit.

Most plant nematodes belong to this order. Examples are:

Aphelenchoides bessayi - a leaf-bud feeder

A. ritzema-bosi - gooseberry-blackberry bushes

Anquina tritici - wheat gall nematode

Ditylenchus dipsaci - stem-bulb nematode of alfalfa, onion, daffodil, garlic and wheat.

D. destructor - potato-stem-gall

Meloidogyne sp. - galls of vegetables, cereals and decorative plants

Heterodera rostochiensis - golden nematodes

H. schachtii - sugar beet eelworm

H. major - cereal root eelworm

H. gottingiana = pea eelworm

Pratylenchus penetrans - root-lesion-burrowing nematodes of grasses, clovers, cereals and tobacco

Radopholus similii - citrus and banana burrower

Rhapinaphelenchus cocophilas - red-herring diseases of coconut palms

CLASS APENOPHOREA (APHASMIDIA)

VI. ORDER TRICHINELLIDA (SUBORDER TRICHINELLINA)

1. Superfamily Trichinelloidea

Typical of this group is the crop worm of poultry, Capillaria annulata and the causal agent of trichinosis, Trichinella spiralis. In tropical regions the whipworm is a common parasite of monkeys, pigs and man. The guts of an Inca girl in Chile buried at 17,658 feet at least 450 years ago was loaded with eggs of Trichuris trichiura,a blood-sucking whipworm.

VII. ORDER DIOCTOPHYMATIDA (SUBORDER DIOTOPHYMATINA)

1. Superfamily Dioctophymatoidea

The genera Hystrichus and Dioctophyma contains parasitic species.

Dioctophyma reviale is the red kidney worm of wild animals and dogs. A leech-like oligochaete worm is the intermediate host.

2. Superfamily Eustrongyloidea

Ill-defined species which infect the proventriculus of aquatic birds.

It will be noted that some orders have not been included in this brief outline of nematode classification and that this outline is not in agreement with Crofton. Nematology is a young science and you should expect changes. Most nematode species are not definitely classified and not all are even found as yet!

EM-4 PLANT PATHOLOGY

PURPOSE:

To assist the student of environmental studies to understand the nature of disease in plants.

MATERIALS:

1. TEXTS AND REFERENCES

Agrios, G. N. 1969. Plant Pathology. Academic Press N. Y.

Albersheim, P., Jones, T. M. and English, P.D. 1969. Biochemistry of the Cell Wall in Relation to Infective Processes. A. Rev. Phytopathol., 8, 301-22.

Arthur, J. C. 1885. Proof that Bacteria are the Direct Cause of the Disease in Trees Known as Pear Blight. Botanical Gazette, Vol. 10,343-345.

Burrill, T. J. 1881. Bacteria as a Cause of Disease in Plants. Am. Naturalist. Vol. 15, 527-31.

Dimond, A. E. 1970. Biophysics and Biochemistry of the Vascular Wilt Syndrome. A. Rev. Phytopathol., 8, 301-22.

Evans, E. 1968. Plant Diseases and Their Chemical Control. Blackwell Scientific Publications, Oxford.

Hollings, M. 1965. Disease Control Through Virus-Free Stock. A. Rev. Phytopathol. 3, 367-96.

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Kosuge, T. 1969. The Role of Phenolics in Host Response to Infection. A. Rev. Phytopathol. 7, 171-94.

Large, E. C. 1940. The Advance of the Fungi. Jonathan Cape, London.

Martin, J. T. 1964. Role of Cuticle in the Defense Against Plant Disease. A. Rev. Phytopathol. 2, 81-100.

Paddock, W. C. 1967. Phytopathology in a Hungry World. A. Rev. Phytopathol. 5, 375-90.

Sequeira, L. 1963. Growth Regulators in Plant Disease. A. Rev. Phytopathol., 1. 5-30.

Stakman, E. C. and Christenson, J. J. 1960. The Problem of Breeding Resistant Varieties. IN Plant Pathology: An Advanced Treatise. Vol. 3 (Ed. J. G. Horsefall and A. E. Dimond), pp. 567-624. Academic Press, N. Y.

Stevens, R. B. 1960. Cultural Practices in Disease Control. IN Plant Pahtology: An Advanced Treatise. (Ed. J. G. Horsefall and A. E. Dimond), pp. 357-429. Academic Press, N. Y.

Tomiyama, K. 1963. Physiology and Biochemistry of Disease Resistance of Plants. A. Rev. Phytopathol. 1, 295-324.

Walker, J. C. 1957. Plant Pathology. McGaw-Hill p/ 374.

Wheeler, B. E. J. 1975. The Control of Plant Disease. Oxford Biology Readers #74. Oxford Unive. Press. p. 16.

Wheeler, B. E. J. 1969. An Introduction to Plant Diseases. Wiley & Sons. p. 374.

Wood, R. K. S. 1974. Disease in Higher Plants. Oxford Biology Readers #57. Oxford Univ.Press. p. 32.

Wood, R. K. S. 1967. Physiological Plant Pathology. Blackwell Scientific Publications. Oxford. p. 570

2. Microscopic slides of major plant diseases.

Carolina Biological Supply Company, Burlington, N. C.

OBJECTIVES: To enable the student to:

1. Follow the development of phytopatholigical thought.
2. Detect plant damage.
3. Measure the effects of disease.
4. Control plant disease.
5. Develop a reading reference in phytopathology.

DATE STARTED: ______________

EM - 4 PLANT PATHOLOGY — **INSTRUCTION & CHECKOFF SHEET**

Plant pathology or phytopathology is an exciting and very vital area of microbiology. Our food, clothing, drugs, and now perhaps much of our energy must come from plants. Phytopathology is concerned with the health and productivity of plants. Research and education in these areas is moving ahead even in these times of slow economic growth. You may find in this area a lifetime of productive activity.

PACKET # 1 - Read Burrill, T. J. - Bacteria as a cause of disease in plants. After this historical article read Arthur, J. C. - Proof that bacteria are the direct cause of the disease in trees known as pear blight. Take notes on 3" x 5" cards for historical file to be included in Packet # 2.

DATE COMPLETED: ______________________
CARDS: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET # 2 - Utilize Walker, Agrios, Stakman or Wheeler's Texts to develop a card file on historical development of plant pathology. Develop a vocabulary section also.

DATE COMPLETED: ______________________
CARDS: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET # 3 - Read the Oxford Reader by Wood, Disease in higher plants. Utilize programmed review.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET # 4 - Read the Oxford Reader by Wheeler, The Control of Plant Disease. Utilize programmed review and submit to instructor technique sheet and F.I.D. sheets.

DATE COMPLETED: ______________________
TECHNIQUE SHEET: ______________________
F.I.D. SHEET: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET # 5 - A PERMANENT REFERENCE TO PLANT DISEASE: PHYTOPATHOLOGY Extend your Data Storage System and your F.I.D. notebook by cross-referencing plants and their pathogens.

DATA STORAGE CARDS: ______________________
F.I.D. SHEETS: ______________________
DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

REQUEST END OF MODULE TEST.

END OF MODULE TEST: ______________ DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ______________________

EM - 4 PLANT PATHOLOGY
PACKET # 1 - Burrill's Article

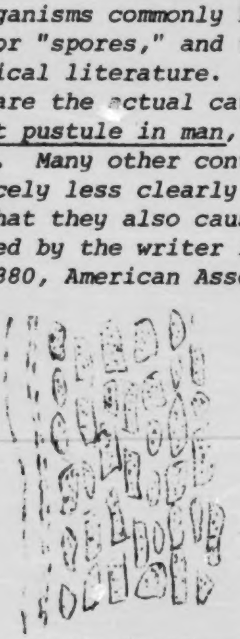
Burrill, T. J., 1881. Bacteria as a Cause of Disease in Plants. American Naturalist, Volume 15, pp. 527-530.

BACTERIA AS A CAUSE OF DISEASE IN PLANTS

From American Naturalist, Volume 15, 1881

By Professor T. J. Burrill

CERTAIN diseases of animals are now positively known to be due to the action of the minute organisms commonly known as bacteria. They are spoken of as "disease germs" or "spores," and the "germ theory" of disease is very fully discussed in medical literature. Among the best proved examples that the so-called germs are the actual cause of disease, we may cite anthrax in cattle, malignant pustule in man, and the diseases of swine and fowl ordinarily known as cholera. Many other contagious diseases of man and the domestic animals are scarcely less clearly known to be due to bacteria, but it has not been shown that they also cause disease and death of plants, except as recently announced by the writer in case of "blight" in pear and apple trees (August, 1880, American Association for the Advancement of Science).



Healthy Pear Bark

Cells filled with starch grains.

x125

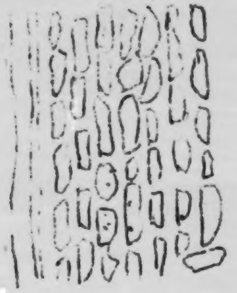
I am now able to add the "yellows" of the peach with much confidence, without, however, the full investigation given to the former disease.

In 1877 I observed in the fluids of blighting pear trees, great numbers of minute, moving things which were not clearly identified as bacteria* until the following year. Their presence was uniformly detected in every examination made (and they were numerous) during the summer of 1878, and the fact was reported to the Illinois State Horticultural Society, in December of that year (Transactions, p. 79). Investigations were not further prosecuted until June, 1880, when the unusual prevalence of the disease called more special attention to it. The same organisms, or those very similar, were as uniformly found in the tissues of apple trees suffering with the disease called twig blight. On diseased parts of both trees, drops of whitish, viscid material were often found, oozing from the bark, and this proved to be almost wholly

*Erwinia amylorora causes fire blight of apple and pear, and all members of ROSALEAE.

made up of the bacteria. After some hours' exposure the mass became yellowish, and finally dark-brown. These bacteria are generally double jointed, each article being about .001 mm. (.0000393 in.) in transverse diameter, and about .0015 mm. long. Sometimes, however, the oval single forms are common, and not unfrequently longer ones of several joints are found.

Upon examining the infected tissues, the absence of the starch granules, so abundant in the healthy cells, was especially marked. Tests revealed the fermentation of this starch with the evolution of carbon dioxide, hydrogen and butyric acid. The other carbonaceous materials in the cells, as sugar, malic acid, &c., doubtless undergoes the same fermentation, but being soluble in water their loss is not rendered evident by the microscope. The cell walls contrary to my expectation, were not found injured, neither was the protoplasm involved in the fermentation.



Diseased Pear Bark
3 weeks after blight commensed
x125 note lack of starch grains.

By passing a thin section of the bark under the microscope, it is possible to find in the same slice, all variations, from perfectly healthy cells to those which have lost the whole of the stored starch, the bacteria likewise varying in numbers as the destruction of the starch bacteria progresses. How these originally gain entrance to the cells was not made out. There are certainly no pores or other visible openings through which they pass. Water, however, is absorbed by the wall cells, and passes through their molecular spaces in all directions. It may be that in the germ condition, the bacteria are really small enough to pass with the water through the walls, notwithstanding the fact the highest powers of our microscopes fail to detect the molecular openings. However this may be, it is positive enough that the adult bacteria do not in this way traverse the cell walls. The evidence is totally against any distribution of the organisms in the tissues by the circulations of water or sap. They slowly make their own way from cell to cell, progressing equally in all directions from the starting point when the same conditions are presented.

On July 1, 1880, I inoculated two pear trees by inserting small pieces of bark from a pear tree in which the desease was in active progress. On the 12th and thereafter, inoculations were made by dipping a clean needle or the sharp point of the blade of a pen-knife into the viscid substance exuding from diseased bark, diluted or not with distilled water, and thrusting the instrument into the experimental trees. Usually three such punctures were made near each other, but the three were counted as one inoculation.

No visible results followed any of these inoculations during the first eight days, and in some cases for two or even three times this period. In the majority of cases ten to twelve days elapsed before external signs of the disease could be observed. No difference was detected in this or any other respect in the different ways of inoculation. But numerous external applications of the virus were made to the bark and leaves without wounding, none of which seemed to communicate the disease. The trees were examined at least once each day until the 14th of August, 1880, and every observed change carefully noted. Very often the disease could be detected by dissections and microscopical examinations when no external indications were presented, but these were not counted as successful inoculations except in very clear cases.

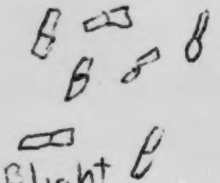
The experiments upon pear trees were made upon trees three years old, Bartlett and Clapp's Favorite, seventy-two in number. The apple trees are Grime's Golden, and the quince, Angers.

The following table gives the results in per cents of the number of successful inoculations:

Number of Experiments	Kinds of Trees	Virus from Pear	Virus from Apple
36	Pear	54	72
29	Apple	30	Not tried
4	Quince	100	Not tried

It will be ovserved that the virus from the diseased apple limbs, was more fatal to the pear than that from blighting pear, showing at least that the disease in the apple is of the same nature as that known as fire blight in the pear. It is quite possible, however, that the greater percentage is due to other causes than the virulence of the inoculating material, and that another set of experiments would show this. The low percentage in case of the apple(30) inoculated with pear virus is partially explained from the fact that ten inoculations were in the bark of portions more than one year old, none of which were successful. As these trees show blight for the most part in the shoots of the current year's growth only, some reason for the failure may be conceived. But four inoculations were made in the quince, all of which communicated the disease. These were made upon the young shoots of a bushy tree which was not otherwise unhealthy.

Since these experiments were made, careful study has convinced me that the death of patches of bark on the trunk and larger limbs of the apple tree is due to the same cause. The disease slowly progresses from the center of infection and kills the tree when the whole circumference becomes involved. Sometimes, however, the liber (the bast cells are not penetrated by the bacteria) forms a complete shield to the inner tissues, and after the outer cellular bark is destroyed a new layer is formed beneath, the old finally falling away.


Blight
bacteria
×1000

Meteorological conditions probably have some influence, but how much and what is not clear. The disease slowly progresses in winter as well as summer, in dry weather as well as wet. The sudden appearance often noted is but the blackening of the leaves upon a branch long diseased.

The slow progress of the malady gives the best hope for successful treatment. It has been considered sudden and irregular, with little or no indications of trouble until destruction came; but this is greatly overstated. Acquaintance with the first appearance in the bark, and careful examination every two or three weeks, will make treatment much more possible than heretofore supposed. The remedy proposed is the old one of cutting away the diseased portions, adding, however, the precaution of taking all infected parts, and not merely such as have become blackish after the ravages are complete, and to ovserve requisite care in cleansing the knife or other instrument, that by the very process of cure the contamination is not spread. Probably carbolic acid or other antiseptic washes may be useful, but proof from actual and indisputable experiment has not yet been reached.

Very recent examinations of material sent from Michigan conclusively confirms my opinion that the yellows of the peach tree is caused by a similar organism. In the cells of an infected shoot I find very little stored starch, but nemerous bacteria. These are seemingly different, under a one-tenth Tolles' or Spencer's objective, from the bacteria of the pear and apple. Compared with the latter, they are long and slender, measuring about .001 mm. by .0035 mm. They consist of several joints, but little longer than wide in what appears to be the typical forms.

The Lombardy poplar trees* are also destroyed by these ferment producing agents, following the attacks of certain wood-boring coleopterous larvae. The latter penetrate the bark and take devious courses through the bark parenchyma and the cambium layer. Starting from their channels, the bacteria slowly spread from cell to cell, until so much of the essential tissue is destroyed that the tree, after some years of hopeless struggle, succumbs. Sometimes the bacteria collect in immense numbers in pockets, which they appear to form in the bark of this tree by absorption of the cell walls. The thick, white mass which they thus form, has the appearance to the unaided eye of pus from sores in the flesh of animals.

The aspen, Populus tremuloides, is similarly affected. The young limbs ** die and the leaves become black in a manner every way similar to those of the pear and the apple.

* poplar dieback and canker

** Pseudomonas syringae var. populea.

EM-4 PLANT PATHOLOGY
PACKET #1 - ARTHUR'S ARTICLE

Arthur, J.C. 1885. PROOF THAT BACTERIA ARE THE DIRECT CAUSE OF THE DISEASE IN TREES KNOWN AS PEAR BLIGHT.[1] Botanical Gazette. Vol. 10. pp. 343-345.

It has now been five years since Professor Burrill brought the subject of pear blight before this Association and announced that it was due to bacteria. Previous to that time no instance of bacteria acting the role of vegetable parasites had been known, and the discovery was therefore a very important one, opening the way to a new and promising field of research.

The experiments of Professor Burrill showed that the disease alluded to was invariably accompanied by a specific form of bacteria (since named Micrococcus* amylovorus Burrill), and that as the disease progressed a colorless or yellowish viscid substance was formed, apparently by the action of the bacteria upon the starch and other substances of the plant. The disease results in the complete death of all those parts of the tree that are attacked.

Although from these and subsequent investigations the theory has been quite generally accepted that the bacteria are the cause of the disease, no rigid proof of it has yet been brought forward. It was with a view to either absolutely prove or disprove the theory that a course of experiments was begun last March, and continued to the present time.

It has been incontestibly shown that the disease may be readily transmitted to healthy tissues by introducing a drop of an infusion made by putting some thin slices of the diseased tissues in water,[2] or by simply transferring a minute portion of the exudation from the diseased to the healthy shoot. The problem was consequently narrowed down to one of two alternatives, either the bacteria were the cause of the disease, or the juices which accompanied them were the cause of it.

The first attempt was to secure some innoculating material in which the bacteria were entirely freed from the juices of the disease. This was done by means of a succession of artificial cultures in a sterilized infusion of corn (maize) meal.

Two series were successfully carried through, extending over about four months, and an innoculation from the sixth culture of each introduced into the green fruit of a Bartlett pear.

The accompanying tables will show the kind of culture vessels used, the amount of culture fluid they contained, and the date at which each one was started. The first culture of the series was infected with a very small

1. Read before the American Association for the Advancement of Science, August, 1885.
2. Arthur, Bull. N. Y. Agric. Exper, Station, xcii: 3rd Ann. Rep. N. Y. Agric. Exper. Station, p. 358.
3. Burrill, Amer. Assn. Adv. Sci. xxix, p. 589; Amer. Naturalist, xv. 529. Arthur, l.c.

* Micrococcus changed to Erwinia.

No. of Culture	Date of Infection	Kind of Culture Vessel	Amount of Fluid
301	March 27	Salmon culture tube	20 cc.
302	April 1	Salmon culture tube	20 cc.
307	April 21	Sternberg culture flask	½ cc.
309	April 24	Sternberg culture flask	½ cc.
314	May 22	Sternberg culture flask	½ cc.
322	June 5	Test tube with Fol stopper	25 cc.
364	July 13	Bartlett pear on tree	

fragment of wood taken from the inner portion of a diseased limb of Flemish Beauty pear, in which the disease had been slowly advancing during the winter, from an inoculation made July 26, 1884, with an infusion of blighted twig from an apple tree. The infection of each of the other cultures of the series was successively made with a small drop of the one preceding. From the last culture a crop was transferred to a puncture in a ripe Bartlett pear. In both cases the pears were soon filled with the disease. They did not turn brown about the wound , as is the more usual way, but first indicated the presence of the disease by beginning to shrivel, which occurred in one case in nine days after inoculation, and in the other in ten days. Upon cutting the pears open the softer tissues were found broken down and liquefied, and a milky viscid juice ran out, showing that the disease had taken thorough possession.

No. of Culture	Date of Infection	Kind of Culture Vessel	Amount of Fluid
301	March 27	Salmon culture tube	20 cc.
302	April 1	Salmon culture tube	20 cc.
307	April 21	Sternberg culture flask	½ cc.
309	April 24	Sternberg culture flask	½ cc.
310	April 27	Sternberg culture flask	½ cc.
320	June 5	Test tube with Fol stopper	25 cc.
362	July 13	Bartlett pear on tree	

By this means of fractional culture the juices accompanying the bacteria first introduced were so much diluted in the transfers to succeeding cultures that the final drop used to inoculate the pear was practically free of them, and to the bacteria only, supplied by continued growth and multiplication, can be ascribed the last result.

Having shown that the bacteria when isolated from their juices are able to cause disease, it still remains to show what action the juices would have when separated from the bacteria. On July 18 a strong infusion of blighted pear

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was filtered through a porous earthenware vessel, such as used for small electric batteries, and an unripe Bartlett pear inoculated with the filtrate and another pear with the infusion used for filtering. In a week the latter was thoroughly blighted, while the former showed no signs of injury except the slight wound, which finally healed. On July 24 another strong infusion of pear blight was filtered through a second battery cell. Both of these cells were new and had never before been used for any purpose. In this case two unripe Bartlett pears were inoculated with the unfiltered infusion and two others on the same tree with the resulting filtrate. Both the former showed strong evidences of the disease within three days, while the latter soon healed up the wounds made by the inoculation, and have continued their normal growth.

The evidence is thoroughly satisfactory and conclusive. The bacteria accompanying the disease of trees known as pear blight when fully isolated will produce the disease, while the juices in which they live will not. They are therefore the direct cause of the disease.

EM-4 PLANT PATHOLOGY
PACKET #2 - HISTORICAL DEVELOPMENT OF PLANT PATHOLOGY

Make sure that you have these 'vocabulary words on your 3" x 5" index cards.

PATHOLOGICAL VOCABULARY:

symptoms
synonymy
causal agent
incitant
saprophyte
pathogenesis
pathogenicity
sclerotia
rust
suscept
inoculum
epiphyte
endophyte
obligate
facultative
endemic
epidemic
epiphytotic

sporadic
fungicidal
fungistatic
urediospore
teliospore
pychia (-spous)
heterothallic
phanerogamic
crypttogamic
mosaic
necrosis
predisposing
parenchyma
polder
hyperplasia
hyperthrophy
exanthema
echinulate

DO YOU RECOGNIZE ANY OF THESE WORDS FROM OTHER MODULES?

EM-4 PLANT PATHOLOGY
PACKET #3 - DISEASE IN HIGHER PLANTS - PROGRAMMED REVIEW

1. Bacteria and fungi for the most part derive their energy from dead ____________ or ____________ material; a few are parasitic on ____________ and ____________. Most work and concern is with those which infect man or his ____________ and ____________, Cramer (1967) estimated total cost of crop loss at ____________ billion, about _____ percent of this countries corn crop.	
2. The main line of attack against plant disease is carried on by ____________ who are developing _______ cultivars that are disease resistant, and in developing materials to kill plant disease _________. In the long run research is needed towards understanding the __________ nature of each ____________.	1. plant animal plants animals plants animals 25 12 15
3. Organisms which grow little or not at all outside of the host plant are called _____________ parasites. These are difficult or ______________ to grow in the laboratory. There are bacteria which are obligate parasites of animals and man, but so far none are known to be ____________ parasites of _________________.	2. phytopathologists new organisms fundamental disease
	3. obligate impossible obligate plants

NOTE: PREPARE KRITTER SHEETS FOR THE FIELD IDENTIFICATION NOTEBOOK BY CONSULTING WALKER, PLANT PATHOLOGY, or other references.

Southern Corn Blight	Helminthosporium maydis
North American Oat Blight	H. Victoriae
Sugarcane Blight	H. sacchari
Powdery Mildew	Erysiphe graminis Sphaerotheca fuliginea
Blackleg of Vegetable	Erwinia carotovora var. atroseptica
Green Apple Rot	Penicillium expansum
Damping - off	Pythium debaryanum
Lettuce Botytis	Botrytis cinera

Bean Botrytis	B. fabae
Bean Halo Blight	Pseudomonas phaseolicola
Wild Fire Tobacco	P. tabaci
Vascular wilt	Verticillium albo-atrum
Potato Ring-rot	Corynebacterium sepedonicum
Leafy gall	C. fascians
Crown gall	Agrobacterium tumefacians
Azalea gall	Exobasidium azaleae
Mint rust	Puccinia menthae
Clubroot of Brassicas	Plasmodiophora brassicae
Corn Smut	Ustiliago maydis
Citrus green rot	Penicillium digitatum
Tomato wilt	Pseudomonas solanacearum
Fire of Tulips	Botrytis tulipae
Apple Scab	Venturia inaequalis
Potato Blight	Phytophthora infestans
Shot-hole of Almond	Clasterosporium carpophilum
Common fruit rot	Monilinia fructicola
Anthracnose of Bean	Collectotrichum lindemuthianum
Onion Smudge	C. circinans

4. The main channels through which nutrients move into the fungus is by _______________. Inside the host cells the host's _______________ protect the invading haustoria. When the plants are attacked some sort of metabolic '_______________' is produced which draws nutrition to the _________________________. Around the infected area a '___________ - ____________' appears which lasts beyond the time when infected tissue _______________ and distant tissue becomes ____________________.

5. Some parasites multiple in nature on dead materials usually in soil or litter. These are the ___________ parasites. These are more easily studied since (so far) few ______________ parasites can be grown 'in vitro'. These organisms damage plants by:

1. producing cell wall destroying ___________
2. secreting protoplast sensitive ___________
3. altering substances in plants which are __________ ___________________.

4. hausteria
   plasmalemma
   sink
   fungus
   green-island
   dies
   chlorotic

5. facultative
   facultative
   enzymes
   toxins
   growth regulators

6. Cell free extracts from diseased tissue affected by facultative parasites still cause disease ____________. The active principle is heat-__________, pH- ____________, high _________ ___________ protein.... apparently an __________.	
7. The critical event in cell separation is the degradation of the insoluble _________________ substances of the middle ___________. Pectic substances are polymers of anhydro- __________ acid. The enzymes secreted by parasites also increases protoplast __________. This destroys host cells and ____________ the local area. The gaseous plant hormone ____________ is involved in the destruction of host tissue.	6. symptoms labile sensitive molecular weight enzyme
8. In some plant diseases soft water rots are not present but instead the pathogens cause tissue to be first ___________ and then _____________. Victoria oat blight is caused by a phytotoxin called _____________.	7. pectic lamella galacturonic permeability waterlogs ethylene
9. Fusarium oxysporum produces a phytotoxin called _____________ ______________. This toxin not only decreases permeability of _______________, but it also ______________iron. The gylcopeptide produced by Corynebacteria act on plasma _________- causing protoplasts to lose ______________. Some vascular wilt bacteria produce _______________ which actually _______________ xylem flow.	8. chlorotic necrotic victorin
10. When Rhizopus spp. attack almond nuts it is the _____________ which spreads and kills local tissue. When the fungus Fusicoccum amygdali attacks almonds and _____________ a toxid ________________ _____________ called 'fusicoccin' spreads to cause tissue damage.	9. fusaric acid protoplasts chelates membranes electrolytes polysaccharides block
	10. toxin peaches diterpenoid glucoside

11. Gibberellic acid is produced by the fungus ____________________ fujikuroi. Other hormones are: _______________, ______________, ________________, _______________, and the 'florigens' or flowering hormones.	
12. The gall producing parasites appear to utilize growth ________________ to upset and control normal growth. Abscisic acid causes a ________________. Helminthosporia often produces growth _______________ hormones which cause bolting and weak growth. Certain Penicillia and Aspergilli produce ____________________ which cause grotesque growth. In coffee leaf drop a growth-regulator of the fungus destroys coffee ___________-______________ ________________ and thus lowers plant growth and hastens leaf fall.	11. Gibberella auxin cytokinin ethylene absciscis adic.
13. Most plants are obviously RESISTANT to disease. Substances are produced by the plants which are ___________________ to parasites. If we understood natural _______________ we might develop methods to control ______________________.	12. hormones stunting stimulating malformins indole-acetic acid
14. A large part of disease _______________ is explicable in terms of _______-_____________ toxins such as the _________________ of tulips and ________________ substances of red onions.	13. toxic resistance disease
15. Resistance can be based upon __________________ features or may be _________________. If pathologists could understand the ______________ phenomena then it might be possible to ____________________ susceptible plants so that they might respond and protect themselves.	14. resistance pre-formed tuliposides phenolic
	15. structural induced hypersensitivity treat

EM-4 PLANT PATHOLOGY
PACKET #4 - THE CONTROL OF PLANT DISEASE

As you proceed through this reading be sure to produce 'kritter sheets' on the diseases: Potato murain or Late Blight; Grape downy mildew; Solanum bacterial wilt; Progressive Hop wilt; Loose Smut; Celery Fungus; Fire Blight; Dutch Elm disease; Pine Rot; Wheat stem rust; Powdery mildew; Cucumber powdery mildew; Southern Corn Leaf Blight; Coffee Leaf Rust; and Yellow Wheat Rust. Use references to complete life cycles, synonymy and treatment.

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1. The causal ____________ of potato late ______________ is Phytophthora infestans. The fungus reproduces via _______________________.	
2. The fungus invades leaf, ____________ and late in the season the _____________ of potatoes. Tubers are often infected when _____________ from the soil at harvest time. To avoid planting the disease with next year's crop the farmer must rotate to disease free fields and use _________ free seed __________.	1. organism (agent) blight zoosporangia
3. NOTE: The Field Key to assessment of potato blight should be in the techniques section of your F.I.D. notebook. This same technique could be modified for any disease you might in the future be fighting against.	2. stem tubers lifted disease (fungus) potatoes
4. Methods used in controlling disease include: 1. control by _________________ 2. production of disease ______ stock 3. complete __________ of the pathogen 4. use of _____________ variety 5. employment of a _________ fungicide 6. spraying or dusting with ____________ fungicide 7. disease control by adjustment of ________ method	3. SHOW TO INSTRUCTOR THE GRAPH AND TABLE YOU DRAFTED.
	4. law free eradication resistant systemic foliar cultural

5. Downy mildew of grape was introduced to France from ______ ______. It is caused by ______ viticola. The fungus is in family ______, Order ______ Class ______. Bacterial wilt is caused by ______ solanacearum which is in family ______.	
6. Although many incitants cause wilt one of the most harmful and common cause of wilt is ______ albo-atrum. This disease organism is a common soil fungus and and is in the Family ______ along with Oospora, Geotrichum, Aspergillus, Penicillium, Botrytis, Mycogone and other members of Order ______ which have colorless or bright colored conidia.	5. North America Plasmopara Peronosporaceae Peronosporales Phycomycete Pseudomonas Pseudomonadaceae
7. Fusarium, Torula, Alternaria and Helminthosporium also are in Order ______, but in the other family in this Order called ______. Here conidia and hyphae are usuallly both ______.	6. Verticillium Moniliaceae Moniliales
8. The smuts affect many ______ including corn, ______, ______ and ______. All of these belong to Order ______. The rusts are another large group within Class ______, Order ______, Within family Ustiliaginaceae are the smuts of corn, oats (two species) and barley; these are Ustilago ______, U. ______, U. ______ and U. ______.	7. Miniliales Dematiaceae dark
9. Common rusts are black stem rust of cereal, Puccinia ______, hollyhock, P. ______ and the incitant of apple-red cedar rust, Gymnosporangium ______-______.	8. grains wheat oats barley (rye, millet, sudan grass maize) Ustilaginales Basidiomycete Uredinales
	9. graminis malvacearum juniperi-virginianae

10. Bacteria (or the Schizomycetes of Nigihi) which are in the order Eubacteriales cause many diseases. The ninety-one species of Pseudomonas and the sixty-two species of ____________________ which cause disease are in the family ____________________.	
11. Diseases are also caused by members of the class Ascomycete. One of these causes Dutch Elm disease, __________________ ulmi. In the same order, ____________________ are the disease organisms which cause chestnut blight __________________ parasitica; anthracnose of sycamore, __________________ platani, bitter rot of apple, __________________ cingulata; and pea blight, Mycosphaerella pinodes. These organisms all have ascocarps which open through a small slit with clavate to cylindrical asci. This places them in the sub-class ____________________.	10. Xanthomonas Pseudomonadaceae
	11. Ceratocystis Sphaeriales Endothia Gnomonia Glomerella Pyrenomycetes

PACKET #5 - A PERMANENT REFERENCE TO PLANT DISEASE: PHYTOPATHOLOGY

Prepare DATA STORAGE CARDS FOR THE BOOKS, ARTICLES, AND REFERENCES used in this module. There is no specific number nor amount of material required in this portion of the module. However, this material may be used during the END-OF- MODULE-TEST. It is suggested that materials be cross-referenced for plant, geography, history, phytopathology, microbiology and/or other areas pertinent. A good KRITTER SHEET includes:

1. Symptoms
2. Causal organisms
3. Disease cycle
4. Synonymy
5. Control
6. References (keyed to Data Storage)
7. Good drawings of:
    - A. whole plant
    - B. infected tissue
    - C. stains used
    - D. stages in pathogenic growth

EM-4 PLANT PATHOLOGY
END OF MODULE TEST

YOU MAY USE DATA STORAGE DECK AND FIELD IDENTIFICATION NOTEBOOK.

MATCHING: CAUSAL AGENT VS. DISEASE

1. _______ take-all disease of wheat
2. _______ fire of tulips
3. _______ leafy gall of carnations
4. _______ blackcurrant leaf drop
5. _______ halo of blight bean
6. _______ light blight of potato
7. _______ loose smut of barley
8. _______ pine rot
9. _______ fireblight of hawthorne
10. _______ white pine blister rust

A. Corynebacterium fascians
B. Pseudopeziza ribes
C. Phytophthora infestans
D. Ustilago nuds
E. Fomes annosus
F. Ophiobolus graminis
G. Erwinia amylovora
H. Cronartium ribicola
I. Botrytis tulipae
J. Pseudomonas phaseolicola

TERMS MATCHING:

1. _______ black scurf
2. _______ Holmes:Johnson:Smith
3. _______ pathogen
4. _______ myxamoeba
5. _______ Krankheitsherd
6. _______ Holocarpie
7. _______ heterothallic
8. _______ hermaphroditic
9. _______ dodder
10. _______ rhizomorphs

A the Plasmodiophoraceae
B. all protoplasmic material used up in reproduction
C. nomenclature of viruses
D. a phanerogamic parasite
E. incitant of disease
F. hypertrophied cells
G. Sclerotia
H. + and - mycelia of different vigor
I. produced by Amillaria root rot fungus
J. any given ascospore line produces ascogonia and antheridia

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DISEASE CONTROL MATCHING

1. _____ benomyl
2. _____ Bordeaux mixture
3. _____ aphid
4. _____ anti Fomes fungus
5. _____ seed soak
6. _____ elm beetle
7. _____ Bintje, Eigenheimer, Voran
8. _____ Avenacin
9. _____ tuliposides
10. _____ a wound cork protection

A. systemic fungicide

B. Myzos pericae

C. Thiram

D. horizontal resistance to Phytophthora infestans

E. resistance of oats to 'take all' disease

F. resistance to Botrutis spp.

G. foliar fungicide

H. cicatrix

I. Peniophora gigantea

J. Scolytus scolytus

CLASSIFICATION MATCHING

1. _____ Rhizopus spp.
2. _____ Alternaria spp.
3. _____ Rhizoctonia solani
4. _____ Verticillium spp.
5. _____ Pythium app.
6. _____ Peach yellows
7. _____ Tylenchida
8. _____ Tilletia caries
9. _____ Armillaria mellea
10. _____ Pucciniaceae

A. Mucorales

B. Mycelia sterilia

C. Moniliaceae

D. Peronosporales

E. Virus

F. Dematiaceae

G. Sacernentea

H. Ustilaginales

I. Uredinales

J. Agaricaceae

EN-5 WATER AND WASTEWATER MICROBIOLOGY

PURPOSE:

To assist the student toward an understanding of the chemistry, biochemistry and microbiology of the water and wastewater field.

MATERIALS:

Mancy, K. H., McClelland, N. and Pohland F. G. Applied Chemistry of Wastewater Treatment. This is an eight unit series which develops the chemical and biochemical background to this subject.

Chambers, C. W. and Clarke, N. .A. Control of Bacteria in Non-Domestic Water Supplies. U.S.D. of Health, Education and Welfare. F.W.P.C.A., Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio.

OBJECTIVES: To enable the student to:

1. Determine relevant biological parameters in a water or wastewater plant.

2. Find the nature and extent of pollution of water samples.

3. Follow reactions which occur in water.

4. Measure dissolved oxygen, organic pollutant levels, inorganic pollutant levels, pH and alkalinity.

5. Control bacteria in water supplies.

DATE STARTED: ____________________

EM-5 WATER AND WASTEWATER MICROBIOLOGY INSTRUCTION AND CHECK OFF SHEET

PACKET #1 - Utilize the first of the Applied Chemistry of Wastewater Programmed Learning Units, hereafter W. W. Units to study the Elements of Biological Wastewater Treatment. Submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2 - WATER AND ITS IMPURITIES
Utilize W. W. Unit #2; submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3 - REACTIONS IN WATER SOLUTIONS
Utilize W. W. Unit #3; submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4 - PRINCIPLES OF ADVANCED WASTEWATER TREATMENT
Utilize W.W. Unit #4; submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #5 - DISSOLVED OXYGEN
Utilize W.W. Unit #5; submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #6 - ORGANIC POLLUTANTS
Utilize W.W. Unit #6; submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #7 - INORGANIC POLLUTANTS
Utilize W.W. Unit #7; submit self-tests on separate sheets.

SELF-TESTS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #8 - pH AND ALKALINITY

Utilize W.W. Unit #8; submit self-tests on separate sheets.

SELF-TESTS: ____________________

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

PACKET #9 - CONTROL OF BACTERIA IN NON_DOMESTIC WATER SUPPLIES

Read Chambers & Clarke. Utilize the programmed review.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ______________

REQUEST END OF MODULE TEST: ________________

END OF MODULE TEST: ________________

DATE MODULE COMPLETED: ______________

INSTRUCTOR SIGNATURE: ______________

EM-5 WATER AND WASTEWATER MICROBIOLOGY
PACKET #9 - CONTROL OF BACTERIA IN NON-DOMESTIC WATER SUPPLIES
PROGRAMMED REVIEW

This article by Chambers and Clarke although not directed at domestic water supplies reviews the problems encountered with bacteria, in both depth and breadth.

---

1. Control is the tailoring of the _____________ quality of water to _____________ dictated by the intended _____________. The demands of a pharmaceutical mamtatomer _____________ much the same as the demands of the power plant.	
2. Non-domestic water does include: _____________ water; _____________ water for farming; _____________ water for factories and power plants; and _____________ waters for the food industry. This article does not consider bacteria which prefer salt water; the so-called _____________ bacteria.	*1. bacteriological specifications use are not*
3. The Public Health Service _____________ _____________ _____________ (1962) regulates allowable _____________ in drinking water. It does not contain criteria for _________- coliform bacteria or other organisms (algae, fungal spores, metazoans). Chlorination _____________ be convenient to food processing plants. Why? _____________ _____________ _____________.	*2. recreational irrigation industrial processing halophilic*
4. The serious offenders in manufacturing and industrial waters are: p _____________, X_____________, F _____________ and A_____________.	*3. Drinking Water Standards coliform non may not because, it can produce off-flavor and is not always completely effective*
	4., Pseudomonas Xanthomonas Flavobacterium Achromobacter

5. The genus ______ includes almost 50% of all bacterial ______ pathogens. These pathogens are easily transmitted by irrigation waters. Even when fecal and total ______ levels are low the human enteric bacteria of the ______ group may be found at dangerous levels.	
6. Pseudomonads and metabolic ______ of ______ are troublesome in ______ and opthalmic solution manufacture. Opthalmic solutions are used in treatment of ______. P ______, A ______, and F ______ have caused problems of food storage and in dairy products. Plasticizers, additives to many industrial products, are often attacked by ______.	5. Pseudomonas plant coliform Salmonellae
7. In flowing water the slimey bacteria ______, iron bacteria in the ______-______ group and ______ cause 'red' water difficulties.	6. products bacteria cosmetic eyes Pseudomonas Achromobacter Flavobacterium Pseudomonads
8. Water, even nominally high-quality ______ water is not free from ______ bacteria. Many bacteria reproduce in water. The most ubiquitous (common and widespread) are the ______.	7. Sphaerotilus nutans Sphaerotilus-Leptothrix Crenothrix
9. The bacterial genera that will grow in water of highest quality include: ______, ______, ______, ______, ______, ______, ______, and ______.	8. distilled viable pseudomonade
	9. Pseudomonas Xanthomonas Achromobacter Escherichia Aerobacter Streptococcus Desulfovibrio Crenothrix

10. Pseudomonas is remarkably successful because they produce ________________ which allow them to utilize ____________ amounts of compounds which kill most other bacteria as their sole ____________ ___ ________________. They can eat t_____________, c___________, chl_____________ and nitro-________________.	
11. Extreme cold alone does not bother bacteria like P _____________, F _____________, A _______________ and ________________. Storage of waters between 0° and 20° Celsius ___________________ sterilize water.	10. enzymes trace source of carbon thymol cresols chlorophenols -phenols
12. Studies by Baylis on filtered, chlorinated, cold water and by Gilcreas, Kelley, Nankivell and Alexander proved that ______________ thrive in ______________ _________________ carrying filtered, chlorinated water which passed normal testing!	11. Pseudomonas Flavobacterium Achromobacter Micrococcus will not
13. Bacteria are so common in laboratory distilled water that Geldreich and Clark state that: "In general, nearly total ______________ of bacteria in distilled water may be the basis for suspecting that water is________________".	12. microorganisms pipe systems
14. Bacteria multiply in ______________ beds, in ion-_____________ units and ___________-type devices. Anerobic organisms _____________ in sand filters and produce ____________ in drinking water. If filters and ________________exchangers are not flushed and ______________ often they can become _____________ and supply 'culture' media for bacterial growth.	13. absence toxic
	14. filter exchange percolation multiply odors ion cleaned incubators

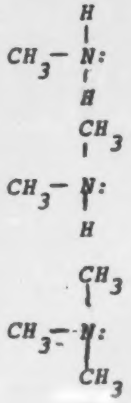
15. Fowler reported problems with ______________ in reactor cooling water. The water from the ion exchanges contained over a _____________ _____________ bacteria per milliliter. The bacteria was 'pure' culture. This may be the result of _____________ _____________ or _____________, either a cause for concern by those advocating nuclear power.	
16. The most dangerous location for bacterial development in distribution lines is a ___________ _____________. Here the low __________ level allows s___________-r _____________ bacteria to grow. Even if the water was chlorinated dead ends and sluggish currents allow accumulation of organic ____________ which uses up the __________.	15. Pseudomonads hundred million(10^8) radiation resistance mutation
17. Other sources of bacterial food in water facilities include: ____________ packings, sulfur _____________ compounds, ___________ gaskets, wooden _____________ vessels, asphaltic ____________ and _____________ used on coolibg towers, storage vats and stand pipes.	16. dead end oxygen sulfate-reducing debris (matter) chlorine
18. Natural ___________ in rivers and lakes is brought about by viral invasion of harmful bacteria by _____________. Some harmless bacteria inhibit other bacteria by an _____________ effect, but there is little evidence that these 'good' effects are very effective when harmful bacteria are prevalent.	17. jute joint rubber storage perservatives sealers
19. In polluted water and especially in sewage or industrial waste lagoons ____________ are the most important bacterial predators. O_____________ and C_____________ are important as bacteria 'eaters'.	18. purification bacteriophages antibiotic
	19. protozoans Oicomonas Colpidium

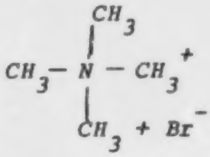
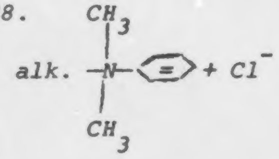
20. Heating water to __________ $^\circ$ Celsius will kill all ____________ bacteria, but not _____________. The bacteria which causes the food poisoning called botulism are called __________ ____________ and are killed in the spore-forming form at 100°C only after _______________ minutes. Ordinary Pasteurization is ___________ $^\circ$ F for ________ minutes. Middle Rapid Pasteurization is ____ $^\circ$F for __________ seconds. Rapid High Temperature Pasteurization is _____ $^\circ$ F for ______ seconds.	
21. Thermoduric bacteria can withstand __________ temperature for ________ times. Thermophilic ____________ can withstand very ________ temperatures continuously. Thermophilic bacteria love high temperature.	20. 100 vegetative spores Clostridium botulinum 330 143 30 161 15 175 20
22. To periodically destroy the built-up levels of ______________ and _____________ bacteria the use of chlorine and its subsequent removal with __________ carbon or ___________-____________ is advocated.	21. high long bacteria high
23. Combined __________ and ___________ brought about almost complete removal of ____________. After this when the water is almost free of ___________ solids a ______________ filter can be used to further reduce bacteria levels. Further disinfection can be obtained using __________ light if carefully controlled. In all of these methods the equipment must be itself periodically thoroughly ______________.	22. thermoduric thermophilic activated sulfur-dioxide
	23. flocculation filtration bacteria suspended membrane U.V. cleaned

EM-5 WATER AND WASTEWATER MICROBIOLOGY
PACKET #9 - CONTROL OF BACTERIA IN NON-DOMESTIC WATER SUPPLIES
PROGRAMMED REVIEW (cont.)

24. Wells and tunnels have often had to be abandoned because of invasion by C__________, B______________ and G______________. These bacteria obtain their carbon from __________-______________, a product of decay and their energy from oxidation of reduced carbonated forms of _____________ and ____________.	
25. Sulfur compounds are attacked by T____________ species while Thiobacillus ____________ oxidizes ferrous iron in streams containing acid mine wastes. This causes __________-___________ when the ___________ hydrates precipitates.	*24. Crenothrix Beggiatoa Gallionella carbon-dioxide iron manganese*
26. Bayliss states: "It is easy to remove microorganisms and avoid other particles by ___________, but it is not easy to ___________ the _________ content of many waters to the point when it will not support __________ growths.".	*25. Thiobacillus ferroxidans red-water ferric*
27. LIST ON YOUR PERMANENT CARDS THE FOUR CLASSES OF GERMICIDES. The first group is comprised of those which are _____________ and includes ______________, ______________ and ______________. Bacteria can become ____________ to these easily. *The second group are not ___________ but microbes can become ________ to them.* *The third group are efficient _________ agents and at high concentration are _________________.* *Bacteriostatic agents prevent increase in population 'short of killing'. They are expensive, non-_______________ and often toxic if let loose into the non-controlled environment.* *The fourth group kills by oxidation. These are usually the best but are often _________ at high concentration.*	*26. filtration reduce organic bacterial*
	27. biodegradable phenols cresols chlorophenols adapted biodegradable tolerant (adapted) bacteriostatic toxic biodegradable toxic

28. The germicidal factor in free chlorine is ____________________, HOCl, (HClO). NOTE: $HOCl \rightleftharpoons H^+ + OCl^-$ OCl^- (or ClO^-) is the hypochlorite anion. Chlorine reacts with water to form this acid. Complete the equation : $Cl_2 + H_2O \rightleftharpoons$ _______ + _______ $+ Cl^-$	
29. In the above equilibrium equation the reaction proceeds to the right, forming ________________ acid when the pH is above __________, or if the $[Cl_2]$ is less than ____________________.	28. hypochlorous H^+ ClO^-
30. The ________________ efficiency of both _______________ and combined _______________ chlorine is directly related to the __________ of the water Increasing pH _______________ germicidal activity. (Note Figure 1). The amount of free available chlorine as HClO decreases as the pH ______________. How much free chlorine is available at pH = 4? __________________ pH = 7? ________________. pH = 11 _____________________.	29. hypochlorius 3 1000 ppm
31. Examining Figure 2, the use of chlorine can be studied. The horizontal axis shows chlorine _______________ in ________________. The left hand axis shows increasing residual ___________________, the right residual ___________________. Residual chlorine is that amount still available after already reacting to kill bacteria in the water. At chlorine concentrations of up to 4 ppm, ammonia and chlorine do not react and combined available chlorine rises to a ____________. Then both combined ________ ____________ and ammonia concentrations drop to a _______________ after which free available chlorine occurs in the water. Breakpoint chlorination for most pollution free waters is about ___________.	30. bactericidal free available available pH decreases imcreases 1 ppm 1.3 ppm 3300 ppm
	31. added ppm chlorine ammonia hump available Cl breakpoint 2 ppm

32. Organic bases are called ________________; structurally they are substituted ______________ compounds.	
33. Draw the Lewis electron dot structure of methylamine (a primary amine). Draw diethylamine. Draw triethylamine. Do you recall who first discovered amines in 1849? Who proposed nomenclature for these organic bases? Who elucidated (worked out) the structures of these decomposition molecules?	32. amines ammonia
34. Consider the reactions which form chloramines from hypochlorous acid and ammonia: $NH_3 + HClO \quad \underline{NH_2Cl} + H_2)$ $NH_2Cl + HClO \quad \underline{NHCl_2} + H_2O$ $NHCl_2 + HClO \quad \underline{NCl_3} + H_2O$ Name the three underlined chloramines.	33.  $CH_3-\overset{H}{\underset{H}{N}}:$ $CH_3-\overset{CH_3}{\underset{H}{N}}:$ $CH_3-\overset{CH_3}{\underset{CH_3}{N}}:$
	34. chloramine dichloramine trichloramine

35. What other oxidizers may be used to replace chlorine? __________ ______________, ____________, ______________ and _________________.	
36. The metal, _______________, is available for use in water treatment. In low concentrations it is _____________. It or its compounds are retained on bacterial cell walls and interfere with reproduction. Another group of compounds with high germicidal activity is the QAC group. This abbreviation symbolizes the ____________________ _______________ ____________________.	35. chlorine dioxide bromine iodine ozone
37. When primary or secondary alkyl halides or aralkyl halide (like benzyl chloride) are heated with tertiary amines Q. A. salts are formed. Show typical reactions.	36. silver bacteriostatic quaternary ammonium compounds
38. Chambers and Parker used alkyldimethyl benzyl ammonium chloride in their experiments. Draw this organic formula. Q.A.C. is very effective against gram-positive bacteria including thermoduric ____________________ and the _____________ formers.	37. $CH_3Br + (CH_3)_3N \longrightarrow$  CH_3Br is methyl bromide; an alkyl halide $(CH_3)_3N$ is tri-methyl amine a tertiary amine.
	38.  micrococci spore

39. *In agricultural waters ____________ used for 'sweetening' soil can also remarkably lower ________________ counts.*

Compounds also highly microbiocidal include sodium penta- ________________, metallic salts of chloro- _______________, chlorinated isopropyl ______________, alkyl derivatives of these, arsenical compounds, and phenyl _____________ compounds. As effective as they are they are also toxic to ____________. Their use is _______________ by good common sense,

---

40. *What are the four techniques used for determining chlorine levels? ___________________________, ________________________, ___________________________, and _________________________.*

39. lime
bacterial
chlorophenate
phenols
phenols
mercury
man
limited

---

41. *Economically what are the best three methods of treating water? __________, ______________, and _______________. Why despite its cost is ozone gaining in popularity as a germicide? ___________________________ ____ ____.*

It is reemphasized that there are great differences in the relative efficiency of different germicides. What appears to be expensive may be economical when all the factors are considered.

40. starch iodide
ortho-tolidine
ortho-tolidine-arsenite
amperometric titrator
HAVE YOU STARTED KRITTER TECHNIQUE SHEETS ON THESE METHODS AS YET?

---

42. *If silver or germicides are used in bottles then they _____________ be used as sample bottles. The time between sampling and bacteriological assay should be ______________. At any rate they should be stored __________________.*

41. chlorine
bromine
calciumhypochlorite
Ozone is made at site via electrical reaction. It removes tastes and color; is less dangerous- but unfortunately it has no lasting residual power.

---

42. should not
minimal (short)
on ice

43. The best method for determining the bacterial content of many industrial (or public) waters is the ____________ ____________ ____________ ______________.	
44. Microscopic examination may provide ________ clues to troublesome problems caused by certain ________-__________organisms. Be especially wary of __________ __________ which may reflect only a small portion of the organisms surviving treatment. Keep some plates ________ __________ then the usual 24 to 48 hours to view slow starters. If you suspect problems try a few plates of specialized media in a search for ______, __________, slime bacteria, A____________, E ____________ and the ubiquitous __________,	*43. total bacteria colony count*
45. The ________ _________ is used to evaluate control of the coli-aerogenes group. It is very meaningful if the index is _________, but beware of low counts since __________ bacteria may still be high.	*44. qualitative slime-forming colony counts much longer anerobes actinomycetes Aerobacter Escherichia Pseudomonas*
46. Silvey and Roach found that if water is not polluted the Gram-__________ genera will be mostly A_________, A _____________ and Pseudomonas, but if sewage is present then so will E________. If Pseudomas aeruginosa appears on plates then look for other bacteria because it is an '__________ __________'. It thrives where pollution bacteria are prevalent.....It competes well.	*45. coliform index nigh total*
	46. negative Alkaligenes Aerobacter Escherichia active antagonist

47. In any water treatment bacteriological tests should be conducted with several different ___________ and several concentrations. Hardness may effect germicidal efficiency so that plate __________________ should be conducted to determine germicidal __________ at the _____________ conditions.	
48. Physical methods of bacteria control are effective, particularly ____________ and ___________________ or a combination of both. Waters containing H_2S or soluble iron require ____________, _________________ and ______________________.	47. germicides counts efficiency use
49. In chemical control the correct selection of ____________ to match water __________ is important. When thermophilic and thermo___________ organisms persist _____________ ___________ is preferred to ________. Nevertheless __________ resistance to some chemical germicides does occur.	48. filtration coagulation (flocculation) impoundment (storage) controlled flow dilution
50. Part of this assignment involves production ot kritter sheets on the important organisms discussed. These include:	49. germicide use -duric chemical treatment heat microbial

Pseudomonas fluorescens
P. aeruginosa
P. viscosa
Xanthomonas sp.
Flavobacterium sp.
Achromobacter sp.
P. fragi
Sphaerotilus natans
Crenothrix sp.
Escherichia coli
Aerobacter aerogenes
Streptococcus aureus
Desulfovibrio sp.
Micrococcus sp.
Vibrio cholerae
Sarcina sp.
Oicomonas sp.
Colpidium sp.
Salmonella typhosa
Clostridium botulinum
Gallionella sp.
Beggiatoa sp.
Thiobacillus ferroxidans
Serratia marcescens
Alkaligenes fecalis
Shigella sp.
Staphylococcus sp.

EM-5 WATER AND WASTEWATER MICORBIOLOGY
END OF MODULE TEST

1. Name using binomical nomenclature ten (10) pathogens or environmental nuisances transmitted by water.

2. At what locations may the investigators expect to find abundant microorganisms?

3. What four physical means may be used to control bacterial growth in water?

4. What chemicals are useful in control of bacteria?

5. What methods are used to evaluate the effectiveness of bacterial control in water or wastewater?

6. Describe a typical primary treatment plant. On a separate piece of paper make a block drawing of one.

EM-5 WATER AND WASTEWATER MICROBIOLOGY
END OF MODULE TEST (cont.)

7. What problems may be encountered during flocculations and settling in basins?

8. What is bulking?

9. When are trickling filters useful?

10. When are lagoons useful?

EM-6 BACTERIA

PURPOSE: To build upon that background in microbiology developed in EM-1 and EM-7 - Bacterial Ecobiology and Microbiological Methods --- a deeper understanding of theory and practice in bacteriologu, especially pathogenic bacteria.

MATERIALS: FILMSTRIPS, REFERENCES

1. Filmstrip - Comparative Pathogenic Bacteriology, Kramer, Theodore T., DvM., M.S., Ph.D. W. B. Saunders Co.

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3. Bailey, W. R. and Scott, E. G. Diagnostic Microbiology, 4th Ed. Mosby.

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EM-6 BACTERIA (cont.)

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26. Marmur, J., Falkow, S. and Mandel, M. New Approaches to Bacterial Taxonomy. Ann. Rev. Microbiol. 17:329.

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28. Pollack, M. R. and Richmond, M. H. Function and Structure of Microorganisms. Cambridge Univ. Press.

29. Rahn, O. Physical Methods of Sterilization of microorganisms. Bacteriol. Rev. 9, 1-47.

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EM - 6 BACTERIA (cont.)

31. Salton, M. R. J. Structure and function of bacterial cell membranes. Ann. Rev. Microbiol. 21:417.

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35. COMMUNICATION SKILLS CORPORATION.

# 8606 - DETERMINING MICROBIAL SUSCEPTIBILITY - KIRBY-BAUER METHOD

8607 - PREPARING BLOOD AGAR PLATES

# 8608 - DIFFERENTIAL WHITE BLOOD CELL COUNT

# 8609 - HOW TO DETERMINE RED BLOOD CELL COUNT

# 8610 - CULTURING ANAEROBIC BACTERIA BY GAS PAK METHOD

# 8611 - HOW TO SEPARATE PLASMA AND SERUM FROM WHOLE BLOOD

# 8615 - HOW TO GROW AND COUNT MICRO-ORGANISMS ON MEMBRANE FILTERS

OBJECTIVES: To enable the student to:

1. Understand the nature of communicable disease

2. Recognize bacterial morphological features

3. Prepare isolation, differential and membrane culture media for both aerobes and anaerobes.

4. Know common human disease organisms

5. Use Bergey's Manual

6. Utilize sterilization procedures

7. Use Kirby-Bauer Disks

8. Make blood agar plates

9. Work with blood samples and separates therefrom

10. Use membrane filters

DATE STARTED: ____________________

EM-6 BACTERIA INSTRUCTION AND CHECK OFF SHEET

PACKET #1 - COMMUNICABLE DISEASES
Read Grisson, D. K. COMMUNICABLE DISEASES. Take end of packet quiz using any kritter sheets and/or data storage cards you produced.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #2 - BASIC MICROBIOLOGY
Read Chapters 7-18 in Skinner, O. C. BASIC MICROBIOLOGY and utilize available references. Complete review questions at the end of the chapters and hand in to instructor for credit.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #3 - COMPARATIVE PATHOGENIC BACTERIOLOGY
Utilize filmstripe on COMPARATIVE PATHOGENIC BACTERIOLOGY by Kramer, T.T. Begin production of kritter sheets on major microbes encountered. Use references available in laboratory. Show kritter sheets to instructor for credit.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #4 - BERGEY'S MANUAL
Utilize reading on HOW TO USE THE BERGEY'S MANUAL. Use the manual to complete kritter sheets of previous packet. Take end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #5 - PHYSICAL METHODS OF STERILIZATION OF MICROORGANISMS
Read Otto Rahn's article PHYSICAL METHODS OF STERILIZATION OF MICROORGANISMS and utilize the programmed review. Take end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #6 - CULTURING ANAEROBES
Utilize handout on anerobic culture methods. Use CSC #8610, CULTURING ANAEROBIC BACTERIA BY GAS PAK METHOD. Culture the anaerobe available or culture a sewage or other suspect sample for anaerobes. Stain the anerobe and show to instructor a plate, slant and slide of a pure culture. Take end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #7
Use CSC presentations 8606, 8607, 8608, 8609, 8611 and 8615. Complete end of packet quizzes and exercises. Make up technique sheets. Choose two of these methods and make up complete laboratory reports.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

TAKE END OF MODULE TEST.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

EM-6 BACTERIA
PACKET #1 - COMMUNICABLE DISEASES - END OF PACKET QUIZ

I. MATCHING

1. ______ Ackerknecht
2. ______ Lister
3. ______ Mantoux-Perquet-Vollmer
4. ______ Sigerist
5. ______ Shick
6. ______ Zinsser
7. ______ Koch
8. ______ Donovan
9. ______ Negri
10. ______ Leff-Samuel-Vera

A. HISTORY OF MEDICINE, 2 vols., London Oxford University

B. cause and prevention of septic infection of wounds

C. causative agent of Granuloma inguinale

D. FROM WITCHCRAFT TO WORLD HEALTH, London Lawrence & Wishaft

E. test to determine immunity to diphtheria

F. tubercle bacillus discovered by....

G. bodies found in brain or rabid animal (and later you if bitten)

H. tests for tuberculosis

I. RATS, LICE & HISTORY, N. Y. Blue Ribbon Books, Inc.

J. A SHORT HISTORY OF MEDICINE, N. Y. Ronald Press

II. MATCH THE DISEASE OR ORGANISM TO THE STATEMENTS:

1. ______ Neisseria gonorrhea
2. ______ hepatitis
3. ______ influenza
4. ______ tuberculosis
5. ______ pneumonia

A. the most deadly, disabling, and debilitating world disease

B. 'glandular' or 'kissing' fever

C. pulmonary infection which may be caused by bacteria, viruses, rickettsiae, or fungi

D. mumps

E. the second place goes to this killer: 15 million in world; 10,000 deaths/ yr. in U.S.

EM-6 BACTERIA (cont.)
PACKET #1

END OF PACKET QUIZ

6. _______	Myxovirus parotiditis	F.	can be treated and fetal infections avoided if found during pregnancy. Silver nitrate used in newborn infant's eyes.
7. _______	infectious mononucleosis	G.	cause inflammation of liver; two forms 'infectious' and 'serum', both viral.
8. _______	Clostridia	H.	respiratory infections caused by Myxovirus. Often epidemic; spread by direct contact
9. _______	malaria	I.	ringworm
10. _______	Microsporum; Trichophytin; Epidermophyton	J.	tetanus and botulism

III. COMMON NAME OF DISEASE V. S. BINOMIAL

1. _______	amoebic dysentery	A.	Plasmodium vivax
2. _______	bacterial food poisoning	B.	Vibrio comma
3. _______	malaria	C.	Rickettsia rickettsiae
4. _______	plaque	D.	Staphylococcus aureus
5. _______	cholera	E.	Haemophitus duereyi
6. _______	Rocky Mtn. Spotted Fever	F.	Neisseria meningitidis
7. _______	Chaneroid	G.	Entameba histolytica
8. _______	meningitis	H.	Salmonella sp.
9. _______	whooping cough	I.	Bordetella pertussis
10. _______	gastroenteritis	J.	Pasteurella pestis

EM-6 BACTERIA
PACKET #4 - BERGEY'S MANUAL QUIZ

1. The first three paragraphs by Buchanan & Gibbons on using the Manual are very apologetic and to some 'unpalatable'. Why? Explain.

2. Describe the three ways in which the keys may be entered.

   1.

   2.

   3.

3. What are "Species Incertae Sedis"?

4. What is a synonym? synonomy? What does the technician consult to research synonymy problems?

5. What is an etymology? Why are these useful?

6. There are seven major areas used to describe bacteria. List them.

   1.
   2.
   3.
   4.
   5.
   6.
   7.

---

7. Murray discusses "A Place for Bacteria in the Living World" and ultimately places them in a separate kingdom, the ______________________. Discuss the basis for division of all life into the above and eucaryotae. Briefly list the criterion.

8. The mitochondria and plastids of eucaryotes could represent the "most extreme form of endosymbiotic parasitism by parocaryotes". DISCUSS.

9. At this time (if you have not already done so) reproduce the chart representing the kingdom Procaryotae on a separate paper.....Then compare to page 9. All your future work with bacteria will use this breakdown. Arrange your F.I.D. notebook to accommodate the modern approach. NOTE: THIS MODERN APPROACH DOES NOT MATCH HOW TO KNOW LIVING THINGS.

10. Cowan and Liston in the Mechanisms of Identification discuss three rules of the game and seven practical steps. They are:

RULES OF THE GAME:

1.
2.
3.

PRACTICAL STEPS:

1.
2.
3.
4.
5.
6.
7.

EM-6 BACTERIA

PACKET #5 - PHYSICAL METHODS OF STERILIZATION OF MICROORGANISMS - PROGRAMMED REVIEW

1. Man fights microbes using two means ____________ and ____________________.	
2. Disinfectants and antiseptics are considered ____________________ means.	*1. chemical physical*
3. Physical means include the use of ______________, ______________, ________________, ________________, or ____________________.	*2. chemical*
4. Change in secondary or tertiary structure of proteins which results in lower solubility and loss of physiological action is called ________________.	*3. heat drying grinding pressure radiation*
5. Drying and freezing food do not ______________.	*4. denaturation*
6. Drying and freezing can be compared to chemical ______________________ rather than with disinfectants.	*5. sterilize*
7. Many people believe that Louis Pasteur was first to use heat to destroy bacteria, but _____________ used heat to produce canned goods long before ______________________ was invented.	*6. antiseptics*
8. During destruction of microbes by grinding processes, no recovery is possible if the ___________________ is injured.	*7. Appert pasteurization*
9. In 1897 Buchner demonstrated _________-_________ ________________. Even though cells were destroyed, yeast cells changed sugar to ____________________ (C_2H_5OH) and __________________-_______________ (CO_2).	*8. nucleus*
10. To the bacteriologist, death results if the power to ________________ is lost.	*9. cell-free fermentation alcohol carbon-dioxide*
	10. reproduce

11. Grinding is more successful than ______________ in causing mechanical injury to microbial cells.	
12. During mechanical destruction of microbes, the death rate is not influenced by: ______________; ______________; or ______________ ______________.	*11. shaking*
13. The rolling and sliding of ______________ particles produced greater grinding action than similar sized angular ______________.	*12. chemistry of the abrasive hardness of the abrasive specific gravity of the abrasive*
14. There is an optimum ___________ involved in grinding processes. With any abrasive, an increase in ______________ above the optimum lovers the ________ ________ and a ___________ also lowers the death rate.	*13. spherical particles*
15. Vegetative cells (those which are involved in colony growth) are more sensitive than spores (sexual reproductive cells) to ______________ injury.	*14. size size death rate decrease*
16. Is it true that spores of different species differ greatly in sensitivity to mechanical destruction? __________.	*15. mechanical*
17. Is it true that cells which are easily destroyed by grinding or shaking are also easily destroyed by heat? ________	*16. yes*
18. Campbell-Renton noted that bacteriophages (virus) that attack bacteria) are ______________ sensitive to shaking than their host bacteria.	*17. no*
19. Bacterial cultures can be freed of ___________ by shaking if they are not heavily infected with the virus.	*18. more*
	19. bacteriophages

EM-6 BACTERIA
PACKET #5 - PHYSICAL METHODS OF STERILIZATION OF MICROORGANISMS (cont.)

20. Pressure has __________ effect upon bacteria in liquid suspension.	
21. Exposure of microbes to ____________ pressure can cause profound effects.	20. small
22. The effect of gas pressure is really __________ ________________________________.	21. gas
23. As early as 1873, it was apparent that high concentrations of _______________ are toxic to microbes.	22. chemical disinfec--tion
24. For complete sterilization of microbes, oxygen concentration must be above _________________ for long periods of time. Tof the Hofius, milk sterilization process 120 psi and ______ ________________ are used.	23. oxygen
25. High ______________ pressure can cause Gram + bacteria to become Gram -. Nitrogen had _______ effect.	24. 75 atmospheres (75 times that of our atmospheric concentration low temperature
26. High CO_2 pressure can cause death by __________ upon depressurization and/or by __________________ of colloid metabolites.	25. hydrogen no
27. Rapid mechanical agitation can be devastating to microbes. One modern technique to accomplish this is the use of ________________ and super-_______________ waves.	26. explosion precipitation
28. The ___________________ of change between compression and release during sonic sterilization is a most important factor.	27. sonic sonic
29. Supersonic destruction of cells allows investigators to remove heat-______________ proteins since they are not ______________________ by sound waves.	28. suddeness
	29. liable (sensitive) destroyed

30. The cause of death by irradiation is the ____________ of some essential cell constituents by the energy of the ____________ rays.	
31. Only the ____________ rays can produce chemical changes.	30. inactivation absorbed
32. For each microbe there is a narrow band of ________ ________ of radiation to which the microbe is very ____________.	31. absorbed
33. It is interesting that differing species of bacteria show little difference in sensitivity to radiation. True or false? ____________	32. wave length sensitive
34. Desiccation death is caused by severe ________.	33. True
35. Death by dessication is greatly influenced by the ____________ in which drying occurs.	34. drying
36. Clinging ________ matter or actual dead ________ provide material which prevents death by dessication.	35. media (material)
37. Drying on metal surfaces kills rapidly. Coins, however, are often contaminated because of clinging ____________.	36. organic cells
38. The death of bacteria which survived drying is really caused by ____________.	37. dirt
39. Bacteria die faster in air or ____________ than in other gases like ________ (H_2) or ________-________ (CO_2).	38. oxidation
40. When it is desired to keep bacteria storage is best done in a ________ at low ________.	39. oxygen hydrogen carbon dioxide
	40. vacuum temperature

EN-6 BACTERIA
PACKET #5 - PHYSICAL METHODS OF STERILIZATION OF MICROORGANISMS (cont.)

---

41. Dry cells display no __________ ____________. Proteins and enzymes _________ destroyed, but are inactivated. The use of dry heat alone _________ always be relied upon for sterilization.	
42. Most bacteria cease to grow at temperatures _________ to _________°C above ___________. At low temperatures they do eventually _________. Death is apparently due to a change in some __________ ___________ ____________.	41. life functions are not cannot
43. If the bacteria *Escherichia coli* is subjected to a change of temperature from 45°C to 10°C rapidly, most all die from ______ _________. In *Nitella clarata*, a common ______________, the process called _________ ____________ ceases if the plant is subjected to rapid temperature drop.	42. 5 10 freezing die essential cell constituent
44. Freezing of microbes causes death by ______ ______________, and _______ ______________. It is ____________ to sterilize foods or even ____________ by freezing!	43. cold shock algae plasma streaming
45. Rapid freezing in liquid air; with a drop of ________________ and subsequent thawing in hot water ________ kill tubercle bacteria. The key to this remarkable reaction is ______________, the forming of a glassy ice, rather than crystalline ice.	44. ice puncturing colloid separation impossible water
46. Death by moist heat is not the same as in _________ ____________. Dry heat is primarily an _________________ process while moist heat death involves the ________________ of some __________ ___________ in the cell.	45. 200°C did not vitrification
47. The standard of comparison of _____________ tolerance of different species was originally the TDP, _____________ ____________ ______________.	46. dry heat oxidation coagulation protein
	47. heat thermal Death Point

---

48. Define Thermal Death Point.

---

49. The shortest time necessary to kill all bacteria in a given suspension at a given temperature is called the ________ ____________ ____________.

48. The lowest temperature at which a suspension of microbe is killed in ten minutes under defined conditions.

---

50. The order of death is _____________. A logarithmic order is possible only when death is due to the destruction of a _________________ _______________ in the cell.

49. Thermal Death Time

---

51. Even for temperature above the maximum, microbial ____________ continue to function. Enzymes are bio-chemical _________________.

50. logarithmic
single molecule

---

52. Just as irradiation can cause lethal _______________, so heat coagulation can prevent _______________. A cell which does not __________ is sterile; it is ______________, but its enzymes are still active. Decreasing enzyme content is a ______________ of inhibited growth.

51. enzymes
catalysts

---

53. Heat ____________ make it possible to compare the heat resistance of different ____________ at the same _________________, or the heat ______________ of one _______________ at ________________ temperatures.

52. mutation
reproduction
reproduce
DEAD
consequence

---

54. Factors controlling death by heat:Environmental microbiologists recognize that sensitivity to heat varies dramatically according to __________. Next in importance to the microbe itself is the _________ in which it is suspended. Although the chemical nature of the medium is important the ______________ of chemicals is more important. Each microbe responds in its own fashion to heat depending upon how long it is exposed in what physicodhemical environment.

53. rates
species
temperature
resistance
species
different

---

54. species
medium
concentration

---

55. The most resistant organisms known are ____________ ________________. Yeast spores are less resistant than bacterial spores, but more resistant than other ________________ or ________________ spores.

56. Several factors influence spore survival; these include thick cell ____________, low __________ content, high ____________ content, ability to be absorbed on porous protective matter, and a difference in protein content of the cell ____________. The temperature of ________________ of spore cell wall protein is ________________ than vegetative cell protein.

55. bacterial spores
fungal
algal

57. Wetting agents and soaps are ____________ detergents. All have ________________ properties. The germicidal power of detergents is ______________ with the surface ________________ effect. If a disinfectant is used, it may react with the detergent and give ____________ germicidal efficiency! The technician must be aware that disinfectants and detergents can either decrease or increase germicidal efficiency and that their simultaneous use usually ________________ efficiency.

56. wall
electrolyte
fat
wall
denaturation
higher

57. efficient
germicidal
interlinked
tension
less
decreases

EM-6 BACTERIA
PACKET #5 - STERILIZATION QUIZ

What are the two basic means of disinfection? Explain and give examples of each.

What are five physical methods of destroying microbes?

1.
2.
3.
4.
5.

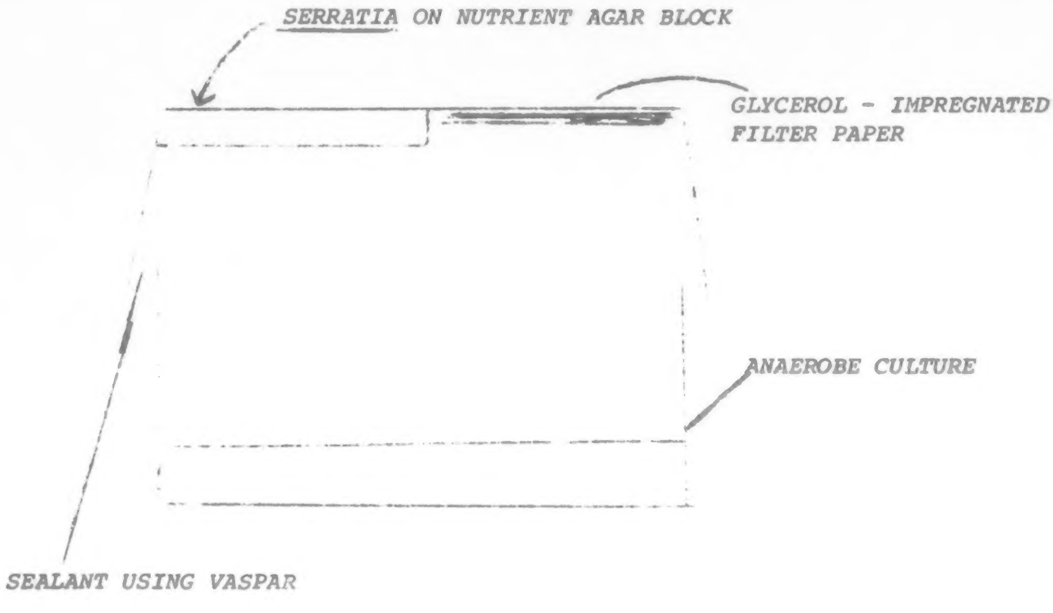
Which is more effective in killing microbes, freezing or boiling? Discuss.

Is it a good practice to use a germicidal detergent and a wetting agent? Discuss.

EM-6 BACTERIA
PACKET #6 - CULTURING ANAEROBES

This procedure uses whatever solid medium on which you wish to grow your anaerobes. In separate Petri dishes using a routine medium such as Nutrient agar or Trypticase Soy agar the surface is swabbed with Serratia marcescens to achieve confluent growth. A portion of this agar surface is cut out using a scalpel or razor blade and placed in the lid of the plate which you have already inoculated with your anaerobic culture. Place the Serratia in the lid so that the inoculated surface extends into the plate. Now invert this plate and, using a disposable pipette, add molten VasPar (50-50 mixture of vaseline and paraffin) around the edges to form a seal. After this sealant solidifies, return the plate to its upright position and incubate as usual. Serratia being a facultative organism will preferentially metabolize aerobically until the oxygen level drops too low; at that time it will switch over to a fermentative metabolism.

One problem encountered with this procedure is that the sealed plate becomes quite humid and the condensate may carry contamination in the form of Serratia onto your anaerobic culture. If possible, the medium to grow your anaerobe should have an increased agar content; alternatively, you can place a piece of filter paper adjacent to the Serratia agar block to which you add a few drops of glycerol. When opening the plates be sure to have a beaker of disinfectant around because it becomes messy.


SERRATIA ON NUTRIENT AGAR BLOCK
GLYCEROL - IMPREGNATED FILTER PAPER
ANAEROBE CULTURE
SEALANT USING VASPAR

EM - 6 BACTERIA

PACKET # 6 - CULTURING ANAEROBES # 8610 - END OF PACKET QUIZ

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1. What important precaution must you observe in using the Gas-Pak method?

2. What ingredient is placed in the screen container? What precaution must be observed when attaching the screen to the lid?

3. When the indicator is blue, what does this denote about the atmosphere in the jar?

4. What type of fluid and how much is pipetted into the generator envelope?

5. After incubation for twenty-four hours at 37°C, the indicator strip should turn _______________ if the atmosphere is suitable for anaerobic growth.

MULTIPLE CHOICE:

1.____Bacteria called obligate anaerobes will not grow when __________ is present in their environment. A. nitrogen B. oxygen C. hydrogen D. carbon dioxide

2.____The Gas-Pak system generates two gases which are : A. carbon dioxide and nitrogen; B. hydrogen and carbon monoxide; C. oxygen and hydrogen; D. hydrogen and carbon dioxide

3.____The color of the Gas-Pak indicator strip when oxygen is present in the environment is: A. red; B. white C. blue; D. yellow

4. With the Gas-Pak system free oxygen is removed from the environment when it combines to form ___________. A. water; B. carbon dioxide; C. nitrogen dioxide; D. sulfur dioxide.

5. The most important precaution to observe when using the Gas-Pak system is: A. Do not agitate jar and contents; B. Do not incubate longer than 24 hrs; C. Do not start or end cultivation procedure near an open flame; D. Do not inhale any of the gases formed.

TRUE-FALSE:

1.___________In the Gas-Pak System, agar plates are incubated upside down.

2.___________Catalyst fragments that may be present in the screen container should be allowed to fall into the jar.

3.___________The indicator strip is exposed at the end of the incubation period to check for the presence of oxygen.

4.__________Open the Gas-Pak jar after five hours incubation to check for bacterial growth.

5.__________If the Gas-Pak system works, water will be formed inside the jar.

ARRANGE THE FOLLOWING STATEMENTS IN SEQUENCE AS THEY WOULD BE DONE IN USING THE GAS-PAK METHOD FOR CULTURING ANAEROBIC BACTERIA.

A. Secure the lid on the Gas-Pak jar.

B. Open jar and check for bacterial growth.

C. Place exposed indicator strip inside jar.

D. Place inoculated plates in jar.

E. Attach catalyst container to lid.

F. Place open generator envelope in jar.

G. Incubate at 37°C for 24 hours.

H. Add 10 ml of tap water to generator envelope.

ASK INSTRUCTOR FOR KEY AND SELF-CORRECT THIS QUIZ. AFTER CORRECTION HAVE QUIZ PUT IN YOUR FOLDER.

NAME:________________________________

DATE:________________________________

PACKET # 7 - #8606 - HOW TO DETERMINE MICROBIAL SUSCEPTIBILITY TO ANTIBIOTICS USING THE AGAR DIFFUSION (KIRBY-BAUER) METHOD END OF PACKET QUIZ

---

1. What do you do if the broth suspension is less turbid than the barium sulfate standard?

2. Describe the technique used to streak the surface of the agar in the petri dish.

3. Describe the technique for positioning the antibiotic discs after they are deposited on the agar surface.

4. What do discs with large clear zones surrounding them indicate?

5. Describe the purpose of the measuring procedure. How does it relate bacterial susceptibility to specific antibiotics?

ARRANGE THE FOLLOWING STATEMENTS IN PROPER SEQUENCE.

A. Thoroughly streak (3 directions) the surface of a 150 mm Mueller-Hinton agar plate with the bacterial suspension.

B. Compare the observed inhibition zone diameters with a Zone-Size Interpretative Chart to determine antibiotic susceptibility.

C. Inoculate samples of five isolated colonies of the bacterial strain to be tested into Trypticase Soy broth.

D. Incubate the agar plate with the antibiotic discs.

E. Use a multidisc dispenser and deposit various types of antibiotic discs on the streaked agar surface.

F. Measure and record any zones of inhibited growth that may surround antibiotic discs.

G. Incubate and/or dilute the bacterial broth suspension so that it matches a barium sulfate turbidity standard.

EM - 6 BACTERIA
PACKET # 7 - #8606 END OF PACKET QUIZ (cont.)

TRUE-FALSE

1.________The agar diffusion technique commonly employs twelve different concentrations of a single antibiotic to determine which concentration is most effective in inhibiting the growth of the microorganism.

2.________The entire surface of an agar medium must be inoculated with the microorganism in the agar diffusion test of antibiotic susceptibility.

3.________The agar diffusion technique is an in vitro test and does not necessarily indicate the sensitivity of a microorganism to the antibiotic in vivo.

4.________Antibiotic discs should be spaced equidistant from each other on the surface of the agar medium.

5.________Several different types of colonies should be mixed together in the tube of Trypticase Soy Broth.

6.________Antibiotic discs are coded by color, shape, or other distinguishing symbol to aid in their identification.

7.________Antibiotic discs must be placed on the agar medium before inoculation of the medium with the microbe if the test results are to be valid.

PACKET # 7 - #8607 - HOW TO PREPARE BLOOD AGAR PLATES - END OF PACKET QUIZ

1. After the blood agar base has been dissolved, you ____________ the flask and autoclave for _____________ minutes.

2. The blood agar base must be cooled to about ______ degrees C before the blood may be added. How do you determine that this temperature has been reached?

3. Two methods can be used to add blood to the flask. What are they and what precaution must be observed with either technique?

4. What is the proper depth of blood agar in the petri dishes?

5. Excessive condensation of water on the petri dish covers results from what cause? Sometimes, this can be avoided by _________ the covers of the petri dishes.

6. After 24 hours, you inspect the plates for ______________.

TRUE-FALSE

1.________A correctly prepared blood agar plate has a smooth appearance and is brown in color.

2.________5 ml of defibrinated sheep blood are added to 500 ml of agar medium in the preparation of blood agar.

3.________Blood agar must be poured in plates to about a depth of 5 mm to completely cover the bottom of the plate.

4.________Small pock marks on the surface of blood agar plates, possibly caused by the presence of air bubbles in the mixture before it solidified, are acceptable.

5.________The proper time for addition of fresh defibrinated sheep blood to liquid agar medium is when the agar medium is too hot to touch.

6.________Unused, presumably sterile, blood agar plates are allowed to remain at room temperature indefinitely.

7.________It may be necessary to leave the cover of a petri dish slightly ajar for a minute or two immediately following the pouring of melted blood agar into the petri dish bottom.

8.________If blood agar plates are properly prepared, the blood cells in the medium will be fresh and retain their original color.

9.________Gentle mixing of blood and melted agar base, rather than vigorous shaking, is the correct procedure.

EM - 6 BACTERIA
PACKET # 7 - #8608 - HOW TO MAKE A DIFFERENTIAL WHITE BLOOD CELL COUNT FROM
A PREPARED SLIDE. END OF PACKET QUIZ

---

1. List the names of the three kinds of granulocytes found in human blood.

A.
B.
C.

2. List the names of two kinds of agranulocytes found in human blood.

A.
B.

3. On a kritter sheet sketch each of the white blood cell types listed in question 1 and 2. Note at least one distinguishing characteristic for each type.

4. What kind of white blood cell is most abundant in normal blood? What kind is second in abundance? Which white blood cell is usually the most difficult to find?

5. Identify all of the white blood cells in a series of three microscope fields selected by your instructor. These fields will contain examples of all five kinds of white blood cells, but all five types will not necessarily be within one field.

6. Perform a differential white blood cell count on a slide selected and previously counted by your instructor who will evaluate your results

---

TRUE-FALSE

1.________Either 0.85% saline or Hayem's solution can be used as diluting fluid for this procedure.

2.________Any finger can be used for this procedure provided the finger is free of abnormalities.

3.________The diluting fluid must be filtered each time before use.

4.________If the cells are not evenly distributed in the counting chamber, the count should not be performed.

5.________In the counting chamber, those cells touching the dividing line to the right and below are counted.

6.________The finger puncture can be made once most of the alcohol has evaporated after cleaning the finger.

7.________The first drop of blood after the puncture should not be used for the cell count.

8.________The stem of the pipet is emptied before filling the chamber by expelling one drop from the pipet.

9.________If the chamber is overfilled, you can withdraw the excess fluid by drawing it back into the pipet provided this is done within seconds of flooding the chamber.

10._______The number of cells in E1 + E2 + E3 + E4 + E5 multiplied by 10,000 gives the number of red blood cells per cubic millimeter of diluted blood.

DEMONSTRATE IN THE PRESENCE OF YOUR INSTRUCTOR THAT YOU CAN PROPERLY COLLECT A SPECIMEN FOR A RED BLOOD CELL COUNT AND FILL THE COUNTING CHAMBER.

COUNT THE NUMBER OF RED BLOOD CELLS IN A CHAMBER BY COUNTING THE NUMBER OF CELLS PRESENT IN THE FIVE COUNTING AREAS AND HAVE YOUR INSTRUCTOR COUNT THE CELLS IN THE SAME CHAMBER.

CHARGE BOTH SIDES OF THE COUNTING CHAMBER WITH THE SAME SPECIMEN AND TREAT IT AS IF IT WERE TWO SEPARATE CHAMBERS. THE RESULTS SHOULD BE VERY CLOSE TO EACH OTHER, DIFFERING NO MORE THAN A FEW CELLS.

UP TO WHAT MARK IS THE PIPET FILLED WITH BLOOD?

UP TO WHAT MARK IS THE PIPET FILLED WITH DILUTING FLUID?

HOW IS CHARGING OF THE COUNTER CHAMBER ACCOMPLISHED?

EM - 6 BACTERIA

PACKET # 7 - #8621 HOW TO SEPARATE PLASMA AND SERUM FROM WHOLE BLOOD
END OF PACKET QUIZ

---

1. What is the difference between the blood sample to be used for obtaining plasma versus the one for serum?

2. Just prior to centrifugation, what is done to the tube containing blood from which serum will be separated?

3. After centrifugation, what is the top layer of material in each tube?

4. How is plasma (or serum) transferred to a separate container?

TRUE-FALSE

1.__________Serum should be separated from whole blood within ten minutes after it has been obtained by venipuncture.

2.__________If there is a crack or other abnormality in the tube, blood should be transferred to a new tube before centrifugation.

3.__________The tube of blood containing the anticoagulant will be used to obtain serum.

4.__________Rimming the tube means to centrifuge the tube.

DEMONSTRATE IN THE PRESENCE OF YOUR INSTRUCTOR THAT YOU CAN SEPARATE PLASMA FROM A TUBE OF WHOLE BLOOD.

DEMONSTRATE IN THE PRESENCE OF YOUR INSTRUCTOR THAT YOU CAN SEPARATE SERUM FROM A TUBE OF WHOLE BLOOD.

ARRANGE THE FOLLOWING STATEMENTS IN THE PROPER SEQUENCE.

A. Rim the appropriate tube.
B. Inspect the tubes for any cracks or other abnormalities.
C. Replace stoppers with the proper type of stopper, if necessary.
D. Carefully remove the serum or plasma.
E. Observe the layer of serum or plasma to insure proper separation has occurred.
F. Centrifuge the specimens.
G. Place the separated serum or plasma in properly marked, clean tubes.

ASK INSTRUCTOR FOR KEY TO SELF-CORRECT THIS QUIZ. HAND IN TO YOUR INSTRUCTOR FOR PLACEMENT IN YOUR FOLDER FOR CREDIT.

NAME:______________________________
DATE:______________________________

PACKET # 7 - #8615 HOW TO GROW AND COUNT MICROORGANISMS ON MEMBRANE FILTERS
END OF PACKET QUIZ

---

1. How is liquid growth medium added to the petri dish?

2. How is the membrane filter removed from the filtration unit?

3. What labels should be placed on the petri dish cover?

4. What is the procedure for calculating the number of microorganisms in 100 ml of sample?

TRUE-FALSE

1._________Counts of microorganisms grown on a membrane filter are sometimes expressed as the number of microorganisms per 100 ml.

2._________It is desirable to have residual droplets (i.e., incomplete saturation) of broth resting on the absorbent pad prior to placement of the membrane filter on the pad.

3._________1.8 to 2 ml of broth will saturate the absorbent pad used in growing microorganisms on a membrane filter.

4._________The tips of forceps may be sterilized by placing them in alcohol and then burning off the alcohol.

5._________The most reliable estimate of the number of microorganisms in a sample can be calculated from a membrane filter containing not less than 20 nor more than 200 colonies.

6._________If more than 200 colonies of microorganisms are found growing on a membrane filter, the number of microorganisms should be counted and the count should be rounded off to the nearest 100 microorganisms.

7._________When a membrane filter in a petri dish is ready for incubation, it should be inverted and then placed in the incubator.

8._________Proper placement of a membrane filter in contact with a broth-saturated filter pad results in an even adherence of the membrane filter to the pad.

9._________It is unnecessary to sterilize forceps used in the transfer of a membrane filter with microorganisms from a filtration apparatus to a petri dish for incubation.

10.________If fewer than 20 microorganisms are counted on a membrane filter following incubation, it is necessary to reincubate the membrane for another 24 hrs before making a count.

GIVEN THE FOLLOWING INFORMATION, CALCULATE THE NUMBER OF MICROORGANISMS IN 100 ml OF THE ORIGINAL UNDILUTED SOURCE.

COLONY COUNT ON MEMBRANE FILTER = 147

DILUTION = 10-Fold or 10^{-1}

SAMPLE FILTERED = 70 ml

EM - 6 BACTERIA
END OF MODULE TEST

---

1. Differentiate between obligate and facultative anaerobes.

2. List and briefly identify the components of human blood.

3. In Bergey's Manual six groups of descriptive data are included..... Describe each.

   A. STRUCTURAL CHARACTERS

   B. BIOCHEMICAL AND NUTRITIONAL CHARACTERS

   C. PHYSIOLOGICAL CHARACTERS

   D. ECOLOGICAL CHARACTERS

   E. GENETIC DATA

   F. TYPE OR REFERENCE STRAIN

4. Describe the Skerman Schema.

5. Differentiate between Schizomycetes and Schizophyceae.

---

6. Differentiate between Procaryotes and Eucaryotes.

7. What are the classes of photobacteria?

I.

II.

III.

8. What are the classes of Scotobacteria?

I.

II.

III.

9. There are seven steps listed as PRACTICAL for properly identifying a bacteria....List briefly these steps and describe.

A.

B.

C.

D.

E.

F.

G.

10. Discuss five ways to sterilize materials used in microbial studies.

EM-7 MICROBIOLOGICAL METHODS

PURPOSE: To show the student of microbial life some of the more widely used techniques used in studying bacteria, actinomycetes, fungi, algae and protozoa.

MATERIALS:

1. Slide casette units from American Institute of Biological Sciences, Communication Skills Corporation, Box 684, Fairfield, Conn. 06439

#8101 - SERIAL DILUTION
#8102 - FILL, EMPTY AND CLEAN A SYRINGE
#8103 - SYRINGE TYPE AUTOMATIC PIPETTOR
#8106 - MICROSCOPIC WET MOUNT
#8601 - ASEPTIC TECHNIQUES IN THE TUBE TRANSFER OF BACTERIA
#8602 - CULTURE MEDIA SOLIDIFIED WITH AGAR
#8603 - POURING AGAR PLATES
#8604 - POUR PLATE TECHNIQUE FOR ISOLATION OF PURE CULTURES
#8605 - STREAKING NUTRIENT AGAR PLATES
#8614 - BACTERIAL SMEARS AND METHYLENE BLUE AND GRAM STAINING

2. Carolina Biological Supply Co. Slide Casette Units

#52-2007 - INTRODUCTION TO MICROSCOPY
#52-1995 - THIS IS THE MICROSCOPE
#52-2000 - HOW TO USE THE MICROSCOPE

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EM-7 MICROBIOLOGICAL METHODS (cont.)

9. Frobisher, M., Sommermeyer, L. and Fuerst, R. Microbiology in Health and Disease. Thirteenth Ed. 1974. W. B. Saunders Co., Philadelphia.

10. Gradwohls Clinical Laboratory Methods and Diagnosis. Seventh Ed. 1970. C. V. Mosby Co., St. Louis.

11. Skinner, O. Basic Microbiology. 1975. The Bobbs-Merrill Co., New York.

12. Todd-Sanford. Clinical Diagnosis by Laboratory Methods. W. B. Saunders Co., Philadelphia.

13. VPA: Anaerobe Manual. 1973. Virginia Polytechnic Institute..

14. Other Microbiology Textbooks and Lab Manuals as one Chooses.

OBJECTIVES: To enable the student to:

1. Produce a serial dilution.
2. Operate a syringe.
3. Run an automatic pipettor.
4, Make a wet mount of any microbe.
5. Transfer microbes from tube to tube.
6. Pour Petri dishes and other plates.
7. Make slants.
8. Streak plates.
9. Stain microbes differentially.
10. Use the microscope including oil immersion.
11. Store slants.
12. Isolate colonies.
13. Describe colony morphology.
14. Count microbes in samples.
15. Use common microbiological laboratory equipment.

DATE STARTED: ____________________

EM-7 MICROBIOLOGICAL MATHODS INSTRUCTION AND CHECK OFF SHEET

PACKET #1 - Utilize the Carolina Biological Supply Slides, filmstrips and casettes.

#52-1995 - THIS IS THE MICROSCOPE
#52-2000 - HOW TO USE THE MICROSCOPE
#52-2007 - INTRODUCTION TO MICROSCOPY

You will demonstrate competence when you produce your first slide.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #2 - Utilize CSC #8614 Bacterial Smears and Use of Methylene Blue, and Gram Stains. Complete slide-casette unit, the end of packet quizzes and after self-corrected hand in toinstructor for insertion in your folder. Read about other staining techniques in BASIC MICROBIOLOGY by Skinner, pgs. 22-24. Complete the Review Questions and hand in to instructor.

DATE COMPLETED: ____________________
METHYLENE BLUE SLIDE: ______________
GRAM STAINED SLIDE: ______________
MICROSCOPE TECHNIQUE: ______________
REVIEW QUESTIONS: ______________
END OF PACKET QUIZ: ______________
INSTRUCTOR SIGNATURE: ______________

PACKET #3 - HANGING-DROP TECHNIQUE: Utilize Handout and produce hanging drop slides of euglenoid, protozoan or other microbes as instructed. Read Chapter 19 in BASIC MICROBIOLOGY to see how direct smears are made. Complete Review Questions.

HANGING DROP SLIDE: ______________
REVIEW QUESTIONS: ______________
DATE COMPLETED: ______________
INSTRUCTOR SIGNATURE: ______________

PACKET #4 - HOW TO USE THE AUTOCLAVE AND OTHER LAB EQUIPMENT: Utilize Chapter 2 and 3 in BASIC MICROBIOLOGY, pgs. 10-16. Complete the Review Questions at the end of the chapters and submit for instructor's comments. The instructor or a tutor will then show you how to use the autoclaves used at NHVTC-Berlin since each autoclave is slightly different.

DATE COMPLETED: ______________
AUTOCLAVE: ______________
LAB EQUIPMENT REV. EX.: ______________
STERILIZATION REV. EX.: ______________
INSTRUCTOR SIGNATURE: ______________

PACKET #5 - SERIAL DILUTION CSC#8101: Utilize slide-casette program and take end of packet quiz.

DATE COMPLETED: ______________
INSTRUCTOR SIGNATURE: ______________

PACKET #6 - SYRINGE AND AUTOMATIC PIPETTOR. Utilize CSC #'s 8102 and 8103. Submit exercises, the related experiences and the end of packet quizzes.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #7 - MICROSCOPE WET MOUNT: Utilize CSC #8106 and the hand-out and take the end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #8 - ASEPTIC TECHNIQUES IN THE TUBE TRANSFER OF BACTERIA: Utilize CSC #8601 and obtain handout. Complete the slide-casette work and request end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #9 - PREPARING CULTURE MEDIA SOLIDIFIED WITH AGAR: CSC #8602 - Utilize this slide-casette program and after reviewing request end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #10 - POURING AGAR PLATES AND ISOLATION OF PURE CULTURES: CSC #'s 8603 and 8604 - Utilize these slide-casette programs, do the exercises and when complete request the end of packet quizzes.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #11 - STREAKING NUTRIENT AGAR PLATES: Read Chapters 7 and 9 in BASIC MICROBIOLOGY. Complete review questions. Utilize CSC #8605 on streaking nutrient agar plates. Complete exercises and end of packet quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #12 - GRAM-STAINING AND MORPHOLOGICAL STUDIES: Complete exercise as given in hand-out.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #13 - COUNTING MICROORGANISMS: Complete exercises as given in hand-out.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

REQUEST END OF MODULE TEST.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

EM-7 MICROBIOLOGICAL METHODS
PACKET #2 - BACTERIAL SMEARS AND USE OF METHYLENE BLUE AND GRAM STAINS. REVIEW QUESTIONS.

---

1. Why is the proper preparation of a stain so important?

2. What is the proper procedure for cleaning glass slides?

3. How do you fix a smear?

4. Why should the smear be permitted to dry before fixing it on the slide?

5. Give the step-by-step procedure of a Gram-staining method.

6. What color will Gram-positive organisms be?

7. What color will Gram-negative organisms be?

8. For what is the acid-fast stain used?

EM-7 MICROBIOLOGICAL METHODS
PACKET #2 - BACTERIAL SMEARS AND USE OF METHYLENE BLUE AND GRAM STAINS
END OF PACKET QUIZ

---

1. When preparing a smear, what two components are mixed on a slide surfact?

2. When only one stain is applied to a slide, what is the procedure called?

3. How is excess stain removed from a smear?

4. What are two methods for drying stained and rinsed smears prior to microscopic examination?

5. When performing the Gram reaction, what is the first stain that is applied to the smear?

6. Which step in the Gram reaction must be individually and very carefully performed on each smear?

7. What reagent is used for the final, counterstaining step in the Gram reaction?

HAND IN TO INSTRUCTOR AND RECEIVE PART II.

END OF PACKET QUIZ.

PART II.

ARRANGE THE FOLLOWING STATEMENTS IN SEQUENCE AS THEY WOULD BE DONE IN PREPARING A BACTERIAL SMEAR FOLLOWED BY SIMPLE STAINING. JUST USE THE LETTERS.

A. Heat-fix the smear.

B. Dry the slide prior to microscopic examination.

C. Transfer a small amount of bacterial culture to the drop of water.

D. Apply a simple stain (e.g. Methylene Blue) for one to five minutes.

E. Place a drop of water on a clean slide.

F. Spread water and bacteria on the slide and allow the mixture to air dry.

G. Rinse off stain from the slide.

H. Place a slide on staining rack.

ARRANGE THE FOLLOWING STATEMENTS IN SEQUENCE AS THEY WOULD BE DONE IN GRAM STAINING BACTERIAL SMEARS. SOME STEPS MAY BE USED MORE THAN ONCE. ARRANGE BY JUST USING THE LETTERS.

A. Decolorize with acetone- alcohol.

B. Rinse under stream of water.

C. Flood the slide with safranin counterstain.

D. Blot carefully with bibulous paper or air dry in rack.

E. Flood the slide with Gram's iodine.

F. Place the slide on the staining rack.

G. Flood the slide with crystal violet stain.

PREPARE BACTERIAL SMEARS FROM THE DIFFERENT CULTURES YOUR INSTRUCTOR WILL GIVE TO YOU WHEN REQUESTED. ASSEMBLE THE SMEARS ON A RACK AND GRAM STAIN THEM. THE STAINED SMEARS WILL BE MICROSCOPICALLY EVALUATED FOR SMEAR PREPARATION TECHNIQUE AND ACCURACY OF THE GRAM REACTION.

EM-7 MICROBIOLOGICAL METHODS
PACKET #3 - HANGING DROP TECHNIQUE

Direct examination of live microorganisms can be extremely useful in determining size and shape relationships, motility and reactions to various chemicals of immune sera. The technique used in this packet is the Hanging Drop Technique and in a future packet you will learn how to make a wet mount slide.

MATERIALS NEEDED:

PROTOZOAN CULTURES
HOLLOW GROUND DEPRESSION SLIDES
VASELINE
XYLENE
A 2% SOLUTION OF CARBOXY-METHYL-CELLULOSE DISSOLVED IN 0.2 MOLAR SUCROSE.
APPLICATOR STICKS OR TOOTHPICKS
INOCULATING LOOPS
MARKING PENCIL

PROCEDURE:

1. Apply vaseline to the edges on one surface of a cover slip with a toothpick and place it on the laboratory table so that the vaseline treated surface is up.

2. Place on the center of the cover slip one drop of the 2% solution of carboxy-methyl-cellulose and one drop from a protozoan culture. Be sure to aerate the protozoan sample before using, Mix the two solutions with the aid of an applicator stick.

3. Make a slight mark with a marking pencil close to the edge of the suspension.

4. Invert a depression slide so that the depression will cover the suspension and lower it onto the prepared cover slip. Press on the slide, gently.

5. Lift the slide and turn it right side up.

6. Locate the wax pencil mark in order to find the hanging drop and then examine the slide under low power. Be certain to reduce the intensity of the light source.

7. Switch to the high-power objective and examine the preparation again.

8. Repeat the procedure for each of the microorganisms provided.

9. Record your findings in the RESULTS AND OBSERVATIONS SECTION.

10. At the conclusion of the experiment, remove the vaseline from the depression slides and cover slips with xylene.

11. Prepare several slides and call instructor to view one which you feel is good, when you have it in focus and slowed down.

RESULTS AND OBSERVATIONS

1. Which of the cultures exhibited vital movement?

2. Which cultures demonstrated Brownian movement?

3. Could specific structures of the protozoans studied be seen? If so, which ones?

4. How did the size of the protozoans in this exercise compare with other microbes you have studied?

DO YOU HAVE THE PROTOZOANS ON KRITTER SHEETS WHICH YOU HAVE SEEN? COMPLETE WITH DRAWINGS? HAND IN TO INSTRUCTOR FOR CREDIT.

EM-7 MICROBIOLOGICAL METHODS
PACKET #3 - HANGING DROP TECHNIQUE
REVIEW QUESTIONS

---

1. What are protozoa?

2. Draw an amoeba.

3. Draw a flagellate.

4. Draw a ciliate.

5. Draw and label the parts of a protozoan.

6. In what type of stool would trophozoites be found?

7. In what type of stool would cysts be found?

8. What makes trophozoites of Entamoeba histolytica identifiable?

9. What is the easiest way to detect protozoans by fresh examination?

10. Why must a careful study be made of a fresh preparation when looking for protozoans?

11. What is the largest of the intestinal protozoa?

12. What is the scientific name of the only flagellate considered to be pathogenic?

13. What conditions does Trichomonas vaginalis cause?

EM-7 MICROBIOLOGICAL METHODS
PACKET #4 - HOW TO USE AUTOCLAVE AND OTHER LAB EQUIPMENT
REVIEW QUESTIONS

---

1. What are the primary functions of a clinical microbiology laboratory?

2. Why is observance of safety rules so important in the laboratory?

3. How are the diseases most likely to be transmitted to the laboratory worker?

4. List the five most important safety rules that should be followed in the laboratory.

A.

B.

C.

D.

E.

5. What procedures should be followed if a container of infectious materials is accidentally broken?

6. What does the term sterilization mean? (Do you have this term on your 3" x 5" index card system as yet?)

7. What are the five methods of sterilization you have learned of in this packet?

A. B. C.

D. E.

8. Which is the best method of sterilization? Give details.

9. What maximum temperature (^{O}F and ^{O}C) does water boiling in an open container reach? Why does the temperature never go above this point?

---

10. When is it wise to use filtration as a means of sterilization?

11. Why is the autoclave considered to be a form of a pressure cooker?

12. A pressure of 15 psi within the autoclave indicates approximately what temperature? °F and °C.

13. What are the three important sterilizing factors provided by the autoclave?

14. Explain the flowing-steam process.

15. Why has the autoclave replaced the boiling water sterilizer?

16. What is the best standard to use for dry-heat sterilization?

17. What products are sterilized by chemicals such as ethylene oxide?

18. Explain how filtration is accomplished for sterilization and how negative pressure is obtained.

EM-7 MICROBIOLOGICAL METHODS

PACKET #5 HOW TO MAKE SERIAL DILUTIONS

The PURPOSE of this module is to assist you in developing appropriate skills to make serial dilutions.

MATERIALS NEEDED: In the Science Lab you will find these materials set up and ready for your use.:

Tape Cassette Recorder and Player
Slide Projector
Instructions for use of materials
9 Test Tubes, 15 x 125 mm
2 5 ml pipettes
10 1 ml pipettes
1 marking pencil
1 test tube rack
1 valved rubber suction bulb for pipette
1 Erlenmeyer flask containing solution A - 10 ml of 0.1N HCl
1 Erlenmeyer flask containing solution B - 10 ml of 0.001N NaOH
1 dropper bottle containing 0.02% phenol red, labeled indicator C
3 beakers, 100ml

OBJECTIVE: To enable you to complete a serial dilution using a sample tube plus eight dilution tubes, smoothly and accurately.

WHAT ARE SERIAL DILUTIONS AND WHY DOES ONE MAKE THEM?

Serial dilutions may be necessary to carry out an analysis of a substance. In some fluids, the color may be too intense or the component of interest, too concentrated for accurate reading on a spectrophotometer. In such cases the sample must be diluted. Often when making bacteria counts, the original sample may have too many bacteria for convenient counting, requiring dilution of the sample for counting.

Dilution means to add a quantity of the original solution to a given quantity of another liquid called a diluent. For example, to make a 1:10 dilution, add 9 parts diluent to 1 part of the original solution. To make a 1:1000 dilution add 999 parts of diluent to 1 part of the original solution. This can be done by pouring the diluent into a sample of the original solution, but a more accurate procedure is to use a serial dilution technique.

In this module, you will learn to make serial dilutions using a combination of two solutions which have been chosen so the results can be checked with a color indicator. The indicator is used only for the learning activities in this module and is not normally used in serial dilution techniques.

PRECAUTIONS TO TAKE WHEN DOING THIS MODULE:

1. Check chemical lables on stock bottles carefully against the module equipment and materials to be sure you are using the correct chemicals.

PRECAUTIONS TO TAKE WHEN DOING THIS MODULE: (cont.)

2. Use caution when transferring liquids. Spilled liquid may cause inaccurate measurements or may contaminate the work area. Spilled acid can result in painful burns or damage to laboratory equipment.

3. IF YOU DO SPILL AN ACID OR AN ALKALI SUBSTANCE: WASH AREA IMMEDIATELY BE IT THE LAB TABLE OR YOUR SKIN. IF SPLASHED INTO EYES (YOU SHOULD BE WEARING SAFETY GLASSES) GO TO FRONT OF ROOM WHERE DOOR IS AND USE EYE WASH IMMEDIATELY. TELL INSTRUCTOR!!!!!!!

CALCULATING AND USING DILUTION FACTORS:

The concentration of the solution being diluted can be calculated from a consideration of the simple ratios of solution to diluent in each tube. In the example illustrated in this program, the original dilution was one part of sample to one part of diluent or 1:2. The dilution factor in each successive tube is as follows:

TUBE #	1	2	3	4	5	6	7	8	9
DILUTION	2	4	8	16	32	64	128	256	512

The concentration of the sample in tube 4, for example, is 1/16th of the original or .063 times the original concentration.

A more practical example of dilution series is a 1:10 dilution factor. This is used when diluting bacterial suspensions.

TUBE #	1	2	3	4	5	6	7	8	9
DILUTION	10	100	1000	10000	100000 (10^5)	10^6	10^7	10^8	10^9

If 0.1 ml of bacterial suspension were added to 0.9 ml of diluent in tube one successive dilutions would continue be adding 0.1 ml of tube one to 0.9 ml of diluent in tube two and so forth. If the original bacterial suspension contained 10^{10} bacteria per ml or 10^9 per 0.1 ml, then we would have only 10 bacteria in tube 8.

Dilation factor x Original sample concentration = $\frac{1}{10^8} \times 10^9$ = 10 bacteria in tube 8.

NOW PUT TAPE INTO CASSETTE PLAYER AND SLIDES INTO SLIDE PROJECTOR AND PROCEED MAKING A SERIAL DILUTION. PUT TECHNIQUE ON KRITTER SHEET AND INSERT IN FIELD IDENTIFICATION NOTEBOOK IN TECHNIQUE SECTION AFTER SHOWING INSTRUCTOR.

AFTER COMPLETING SERIAL DILUTION TAKE END OF PACKET QUIZ (RECEIVE FROM INSTRUCTOR) SELF-CORRECT AND HAND IN TO INSTRUCTOR SO THAT YOU WILL RECEIVE CREDIT FOR THIS PART OF THE MODULE. YOU WILL NOT BE GRADED ON THIS. THIS POST-TEST IS JUST FOR YOU TO SEE WHAT YOU UNDERSTAND AND HOW MUCH YOU UNDERSTAND IN THIS TECHNIQUE. IF YOU FEEL THAT YOU DO NOT UNDERSTAND SUFFICIENTLY REPEAT TAPE.

EM-7 MICROBIOLOGICAL METHODS NAME: ____________
PACKET #5 - HOW TO MAKE SERIAL DILUTIONS - END OF PACKET QUIZ DATE: ____________

---

1. Convert to Scientific notation:

A. .000003 ____________ B. .001 ____________ C. .0000015 ____________

D. 123000 ____________ E. 153000000 ________ F. 100000000 ____________

2. Convert to real numbers in decimal form:

A. 10^{-4} ____________ B. 10^{8} ____________ C. 10^{-6} ____________

D. 10^{5} ____________ E. 10^{-3} ____________ F. 10^{9} ____________

3. Arrange the following statements in the proper sequence for preparing a serial dilution of solution A using solution B as a diluent. Use a nine test tube series. Place sequential number in space provided next to letter.

_____ a. examine solutions in each tube to see if they are progressively lighter in color for each dilution.

_____ b. Place 1 ml of solution A in tubes 1 and 2.

_____ c. Number the test tubes in consecutive order from 1 to 9.

_____ d. After transfer, mix the solution in the tube. Then transfer 1 ml of solution into the next tube until the dilution sequence has been completed.

_____ e. Place 1 ml of solution B in tubes 2 and 3.

_____ f. Thoroughly mix the solution in tube 2, then transfer 1 ml from tube 2 to tube 3.

4. When making serial dilutions, the liquid added to the sample is called the ________________.

5. A clean pipette is used for each successive dilution. Why?

6. Describe the procedure used to obtain thorough mixing in each tube.

WHEN THIS IS COMPLETE ASK FOR ANSWER SHEET AND CORRECT THIS. SUBMIT TO INSTRUCTOR FOR CREDIT FOR THIS PART OF THE MODULE.

EM-7 MICROBIOLOGICAL METHODS
PACKET #6 - CSC #8102 - HOW TO FILL, EMPTY AND CLEAN A SYRINGE
USING ASEPTIC TECHNIQUE
END OF PACKET QUIZ

---

1. What type of syringe would most accurately dispense 1.0 ml? Why?

2. Describe the procedure for aseptically inserting the barrel into a glass syringe. Is it necessary that the forceps be sterilized for this procedure?

3. Why is the gauze sponge left on top of the vial after cleaning?

4. Why is air injected into the vial before withdrawing fluid? What is the purpose of this operation?

5. Are tap and distilled water rinses sufficient cleaning for a glass syringe? Why or why not?

6. Describe the steps in preparing a glass syringe and needle for sterilization.

7. What is the recommended procedure for disposing of plastic syringes and needles?

8. ARRANGE THE FOLLOWING STATEMENTS IN SEQUENCE AS YOU WOULD DO THEM IN FILLING A SYRINGE.

A. REMOVE AIR BUBBLES FROM THE SYRINGE AND CHECK VOLUME
B. INJECT AIR INTO THE VIAL
C. SELECT PROPER SYRINGE AND NEEDLE SIZE
D. PREPARE AND/OR CHECK INJECTION FLUID
E. CLEAN VIAL CAP AND LEAVE SPONGE IN PLACE ON CAP WHILE YOU ASSEMBLE SYRINGE
F. PLACE SYRINGE IN STERILE WRAPPER FOR INJECTION BY ANOTHER TECHNICIAN
G. WITHDRAW FLUID FROM VIAL INTO SYRINGE
H. ASSEMBLE SYRINGE WITH NEEDLE

EM-7 MICROBIOLOGICAL METHODS
PACKET #6 - CSC #8103 - HOW TO USE A SYRINGE TYPE AUTOMATIC PIPETTOR
END OF PACKET QUIZ

---

1. List two types of liquid materials that should not be dispensed with an automatic syringe type pipettor.

2. Under what conditions would you dissemble and clean the syringe in detergent.

3. How often should you check the syringe calibration?

TRUE-FLASE

____ A syringe type automatic pipettor is used for volatile substances.

____ A syringe type automatic pipettor is never used to deliver pathogenic organisms.

____ If the lock not on the pipettor shaft loosens easily, it should be tightened with pliers.

____ A syringe type automatic pipettor must be primed and adjusted for proper volume before the pipetting operation is begun.

____ Syringe type automatic pipettors can be soaked in detergent for cleaning.

____ If the pipettor continues to have bubbles in it, tighten the Luer-loc cannula delivery tip and the lock nut.

____ If the plunger moves freely after the assembly is removed, the trouble is in the valve assembly.

____ To clean the valve assembly, disassemble and boil it in strong cleaning solution.

____ The graduations on the syringe can be used for fine adjustment.

ARRANGE THE FOLLOWING STATEMENTS IN PROPER SEQUENCE

A. To remove the pipetted liquid, fill and empty the syringe with tap water 15-20 times.

B. Prime pipettor with water.

C. Check the volume with a dry graduated cylinder after filling 20 tubes.

D. Coarse adjust the volume with the liquid to be pipetted.

E. While you are pipetting, check for bubbles in the filled pipette.

F. Using a graduated cylinder, fine adjust the volume before beginning to pipette.

G. Check the lock nut for tightness after filling every tenth tube.

H. Begin to fill the first tube.

I. After priming, place weighted intake and tubing into the flask of liquid to be pipetted.

J. After filling and emptying the pipettor with tap water, rinse with distilled water.

EM 7 MICROBIOLOGICAL METHODS
PACKET #7 HOW TO PREPARE MICROSCOPE WET MOUNTS

PURPOSE To assist you in developing appropriate skills to prepare microscope wet mounts.

EQUIPMENT AND MATERIALS NEEDED:

a. compound microscope with light source
b. 6 glass microscope slides
c. 7 cover slips
d. 1 well microscope slide
e. 1 pair forceps
f. 1 dissecting needle
g. 1 beaker containing water
h. Kim Wipes
i. nylon threads - cut to about 1" long
j. 1 human hair
k. 1 bottle of yeast cell suspension with dropper cap
l. toothpick
m. Ringer's solution
n. Protozoan culture with dropper cap
o. vaseline
p. test tube
q. methylene blue
r. glycerine

YOU WILL FIND THIS MATERIAL SET UP IN BACK OF THE SCIENCE LABORATORY WITH A CASSETTE PLAYER AND SLIDE PROJECTOR.

OBJECTIVES: To enable you to prepare:

1. a simple wet mount
2. a wet mount using glycerine as a liquid support
3. a wet mount using nylon thread as a support
4. a sealed wet mount
5. be able to stain a wet mount using two different techniques

WHY MAKE WET MOUNTS AND HOW DO YOU MAKE THEM?

Water is the liquid most commonly used for temporary wet mounts. For living plants and animals, the pond water or sea water in which they live is most suitable. Animal tissues are often placed in a salt solution that approximates that found in the living organism. These are called isotonic solutions. When cell structures (organelles) are to be observed, the tissues are frequently stained to make the internal parts distinguishable.

Objects appear more transparent as wet mounts than as dry mounts. This is because light passing through glass and water closely resembles its passage through the microscope lenses. More light can pass through an object being viewed in a liquid especially if it is small or only a few cell layers thick.

Glycerine can be mixed with water when it is necessary to avoid excessive evapoeation, prevent tissue swelling, or to provide additional liquid support for the cover glass.

Vaseline is used to make a more permanent type of wet mount. Water does not evaporate readily from this type of mount and yet some gas exchange can take place across the vaseline barrier to provide necessary oxygen.

PRECAUTIONS TO TAKE DOING THIS MODULE:

1. Handle glass slides and cover glasses only very carefully. Slides and cover slips break very easily and when they do they can cut the skin and even become imbedded in the skin.

2. Handle glass slides and cover glasses only by the edges. Touching the flat surface leaves fingerprints which will distort the image through the microscope. If fingerprints are left on the glass for extended periods of time they will etch into the glass and ruin the slide. REMEMBER TO CLEAN SLIDES THOROUGHLY AFTER USE AND BEFORE USING WIPE DUST OFF WITH A KIM WIPE.

3. Handle specimens carefully using instruments such as forceps, a medicine dropper or a dissecting needle.

4. Be sure to use the correct solutions for mounting each specimen. Incorrect solutions can damage or distort a specimen.

5. Use supports under the cover glass for relatively thick specimens, and for those in which room for movement is needed.

NOW PROCEED WITH THE TAPE AND SLIDES AND MAKE THE SLIDES AS SHOWN. WHEN COMPLETED SUBMIT THE SIX SLIDES TO THE INSTRUCTOR AND TAKE THE END OF PACKET QUIZ TO OBTAIN CREDIT. AFTER INSTRUCTOR NOTATES THE SIX SLIDES ON YOUR POST EVALUATION EXAM, TAKE THE EXAM, SELF-CORRECT AND HAND IN TO THE INSTRUCTOR.

EM-7 MICROBIOLOGICAL METHODS
PACKET #7 HOW TO MAKE MICROSCOPE WET MOUNTS
END OF PACKET QUIZ

NAME: ________________

DATE: ________________

I. PREPARATION OF SLIDES:

The specimens on all completed mounts must be clearly visible when viewed under a microscope's low power objective. The first four mounts must be completely free of air bubbles. If specimens are not clearly visible on all mounts or air bubbles occur on the first four mounts, remake the mounts.

1. A simple wet mount using water and a hair.
2. A simple wet mount using Ringer's solution and cheek cells. Apply methylene blue stain after the cover glass is in place.
3. A simple wet mount using Ringer's solution and cheek cells. Use a previously prepared methylene blue stain slide.
4. A wet mount using water, glycerine and yeast cells.
5. A wet mount using water and protozoa with nylon thread as a cover glass support.
6. A sealed wet mount using water and protozoa. Use vaseline as a seal and nylon thread as a support.

INSTRUCTOR'S SIGNATURE THAT SLIDES ARE COMPLETED: ____________________

II. REVIEW EXERCISE:

1. Why is the cover slip placed over the liquid at an angle?

2. What is the purpose of the procedure shown in the slides for using a paper towel or Kim Wipe to in making a slide?

3. When would you use nylon thread in making a slide?

4. When would you use a water/glycerine mixture?

5. When do you use a sealed wet mount procedure?

PACKET #8 USE OF ASEPTIC TECHNIQUES IN THE TUBE TRANSFER OF BACTERIA

INTRODUCTION:

The purpose of this packet is to assist you in developing the skill of completing a test tube transfer of bacteria using aseptic techniques to prevent contamination.

In addition to the audio visual materials,CSC #8601, the following items will be needed:

1. *test tube rack*
2. *1 nutrient agar slant inoculated with a pure culture of bacteria*
3. *2 uninoculated nutrient agar slants with cape*

4, *1 inoculating loop*
5. *1 Bunsen burner*
6. *one roll of masking tape*

OBJECTIVES:

1. *enable you to aseptically transfer bacteria to an uninoculated agar slant to start a new pure culture.*

2. *to enable you to transfer bacteria smoothly and efficiently.*

WHY?

Because bacteria are present everywhere, it is necessary to use extreme care not to introduce unwanted bacteria into the pure culture. Unwanted bacteria may be introduced by direct contact with contaminated surfaces, hands, and by way of air currents. This packet will show how to keep outside bacteria from contaminating the transfer culture. By learning to handle bacteria correctly, only the desired organism will result in the transfer culture. A pure culture will have only one type of bacterial growth.

PRECAUTIONS:

1. Cloth or other materials that burn should be removed from the top of the work area. The table top should be sterilized with germicide before beginning work.

2. Inoculating loops should only be touched or picked up by the handle. This will prevent serious burns and/or the spread of bacteria onto fingers.

3. Do not heat the agar in the agar blanks, only the top of the tube.

4. Do not allow the test tube mouth to come into contact with anything except the cap.

Go through programmed materials and do the procedure as stated in the program.

After completing the assignment - tape the three tubes together marking the tube with the culture grown with an 'X' - so that you can check your growth in the tubes that you inoculated with the growth of the prepared culture. You will also use your culture to inoculate agar plates in Packet #10 of this module. Place your name on the tape.

REQUEST END OF PACKET QUIZ FROM INSTRUCTOR.

BE SURE TO PLACE THIS TECHNIQUE IN THE TECHNIQUE SECTION OF YOUR F.I.D. NOTEBOOK.

EM-7 MICROBIOLOGICAL METHODS
PACKET #8 END OF PACKET QUIZ

After completion request key from instructor so that it may be self-corrected.

1. In the space provided list the letters of the following statements in the correct order for performance of the aseptic technique for transferring bacteria from one tube to another.

1. _____	A.	Insert the inoculating loop into the stock culture and remove a small smount of bacteria.
2. _____	B.	Remove the cap from the test tube close to your right hand.
3. _____	C.	Transfer a small amount of bacteria to the surface of an uninoculated slant moving from bottom to top with a side-to-side sweeping motion.
4. _____	D.	Flame the inoculating loop wire to redness and place it in the rack.
5. _____	E.	Allow the loop to cool for approximately 30 seconds.
6. _____	F.	Remove the second cap from the other test tube.
7. _____	G.	Flame the neck of the uncovered tubes, being careful to hold the tubes nearly horizontal while they are uncapped.
8. _____	H.	Heat the inoculating loop until all of the nichrome wire is heated to redness.
9. _____	I.	Flame the neck of both tubes and replace each cap on its tube.

2. Why do we flame the inoculating loop?

3. The inoculating loop should be ___________ before inserting into the bacteria. Why?

4. Why are the mouths of the test tubes flamed?

5. Why should the same caps go onto the test tubes from which they came?

6. Is it necessary to reflame the inoculating loop after completing the transfer? Why or why not?

List five possible sources of contamination in the bacterial transfer technique.

EM - 7 MICROBIOLOGICAL METHODS
PACKET # 9 - #8602 PREPARING CULTURE MEDIA SOLIDIFIED WITH AGAR

The Purpose of this packet is to assist you in developing appropriate skills to prepare culture media solidified with agar from commercially available dehydrated media powder.

MATERIALS NEEDED:

500 ml graduated cylinder
combination hot plate magnetic stirrer
water bath
glass beads
1000 ml flask or beaker
weighing boat
spatula
double-pan balance
asbestos gloves
magnetic stirring bar
Celcius thermometer
pH meter
2 pipettes
1000 ml Erlenmeyer flask
large funnel
ring stand to support funnel
autoclave
nutrient agar
1/10 N hydrochloric acid
1/10 N sodium hydroxide
petri dishes

INTRODUCTION:

Agar is often used as a base for culture media because it is a substance which few organisms can digest and it aids in making the media solid, somewhat like gelatin. Agar is better than gelatin for microbiology because it melts at about 85 degrees Celsius and once melted, stays melted until it reaches 42 to 45 degrees Celsius.

Specific agar media is available in dry powder form. Directions for mixing, adjusting the pH, dispensing and sterilization are given on the medium container. This packet will show you how to prepare agar culture media from the dry powder.

SAFETY PRECAUTIONS:

1. *Handle freshly melted agar with care. If spilled, it clings to the skin and produces painful burns.*
2. *Use a water bath when melting agar media. If melted over direct heat, it may stick to the bottom of the flask, boil over, or the glass container may break.*
3. *When using screw tops on glassware, make sure they are loose when placing them into an autoclave.*
4. *When adjusting pH, handle acids or bases with care. Do not allow liquid to enter the rubber bulb of the pipette.*
5. *Replace the lid on the bottle of dehydrated agar medium as soon as you are finished with it.*
6. *Clean agar from glassware immediately after use.*

EM - 7 MICROBIOLOGICAL METHODS
PACKET # 9 - #8602 PREPARING CULTURE MEDIA SOLIDIFIED WITH AGAR
END OF PACKET QUIZ

To heat dehydrated agar culture media, you use a water bath. Why?

Agar melts at about ________°C and solidifies at about _______°C.

When you weigh out the dehydrated media, you must be careful to put the cap back on the bottle immediately. Why?

If the pH of the agar culture media is too high, (alkaline), you add ___________. If it is too low, (acidic) you add _____________.

To sterilize the 500 ml of agar culture media, autoclave for ______ minutes at _______lbs.

6. What are the consequences if the pH of the culture media is improperly adjusted?

ARRANGE THE FOLLOWING STATEMENTS IN THE PROPER SEQUENCE FOR PREPARING AGAR CULTURE MEDIA.

A. Allow the media to cool for 5 minutes and then use a thermometer to determine when it has cooled to 60 degrees C.

B. Clean the work area and set up the water bath.

C. Remove the cooled media from the autoclave and tighten the bottle cap.

D. Check the media after 24 hours for contamination.

E. Weigh 12.5 grams of dehydrated media.

F. Check and adjust the pH of the media.

G. Add the dehydrated media to distilled water in a flask which contains a magnetic stirrer bar, and place the flask into a water bath.

H. Pour the melted media into a bottle, cap loosely and place in the autoclave.

I. Turn on the magnetic stirrer and hot plate and bring media and water to a boil.

J. Autoclave for 30 minutes at 15 pounds pressure. Clean the work area while the media is being autoclaved.

ASK INSTRUCTOR FOR KEY TO SELF-CORRECT THIS QUIZ. HAND IN TO YOUR INSTRUCTOR FOR INSERTION IN YOUR FOLDER FOR CREDIT FOR THIS PACKET.

NAME:______________________________

DATE:______________________________

EM-7 MICROBIOLOGICAL METHODS

PACKET #10 POUR PLATE TECHNIQUE FOR ISOLATION OF PURE CULTURES

OBJECTIVE: TO TEACH YOU TO POUR AGAR PLATES AS WELL AS ISOLATING PURE COLONIES.

MATERIALS NEEDED:

1. Program 8604 - slides and cassette
2. Water bath at 50 degrees C
3. One sterile water blank
4. Three agar tubes
5. 1 each hot plate stirrer
6. One inoculating loop
7. One grease pencil
8. Tube of bacteria from Packet #3
9. 3 sterile petri dishes

INSTRUCTIONS:

1. Put three tubes of agar in beaker with water and heat on heating plate until agar melts. Place in water bath until agar cools so as not to kill inoculant.

2. With inoculating loop transfer from your tube of bacteria a loopful to tube of water blank aseptically. Set aside.

3. With grease pencil mark three test tubes 1, 2, & 3 and sterile petri dishes accordingly.

4. When agar is cool aseptically transfer on loop of bacteria from water blank to agar test tube #1. Swirl. Flame loop. Replace agar tube in 50°C water bath.

5. Transfer one loopful from test tube #1 to test tube #2 aseptically. Swirl. Flame loop. Replace in water bath.

6. Transfer one loopful from test tube #2 to test tube #3. Swirl. Flame loop.

7. Now pour agar into petri dishes as per slides.

8. Close covers on petri dishes and incubate petri dishes at room temperature.

EM-7 MICROBIOLOGICAL METHODS
PACKET #10 - SELF QUIZ

---

1. You put the agar tubes in boiling water to ____________________ the agar.

2. You put the tubes when liquid in a 50°C water bath to ____________________ the agar and keep it in a ____________________ state.

3. Why do you keep reflaming loops after transfers?

4. Why must all equipment used be sterile?

5. Why do you transfer from the water blank to tube one, then to tube two, then tube two to tube three?

6. What should your colonies look like after they grow? Explain by drawing what they would look like on the three petri dishes.

EM-7 MICROBIOLOGICAL METHODS
PACKET #10 - CSC #8603 - HOW TO POUR AGAR PLATES
END OF PACKET QUIZ

---

1. Why is the agar culture medium melted in a water bath?

2. Why is the temperature of the agar medium important?

3. What is the proper depth of the agar medium in the petri dish?

4. If you are pouring a series of plates, how often should you flame the mouth of the flask?

5. The agar in a plate that you poured is lumpy. What caused this?

6. The cover of your petri dish is wet. What causes this and how can it be prevented?

7. ARRANGE THE FOLLOWING STATEMENTS IN SEQUENCE AS THEY WOULD BE DONE IN POURING PLATES. ASSUME THE AGAR HAS BEEN MELTED AND IS READY TO POUR.

    A. Reflame the neck of the flask and replace the cap.

    B. Wash your hands.

    C. Light the gas burner.

    D. Remove the cap and flame the neck of the flask.

    E. Pour the medium into the first plate.

    F. Open the first plate.

    G. Replace the lid on the first plate.

    H. Gently rotate the first plate on the work surface if the agar does not cover the bottom evenly.

    I. Clean the work surface.

    J. Set out the plates, the agar medium and the gas burner.

    K. Turn off the gas burner and clean the work area.

    L. Repeat the pour procedure for additional plates.

EM-7 MICROBIOLOGICAL METHODS
PACKET #11 - STREAKING NUTRIENT AGAR PLATES
REVIEW QUESTIONS

---

1. Where in nature are bacteria found?
2. Define bacteria.
3. How are the size of bacteria measured?
4. What does morphology mean?
5. What are the three main shapes of bacteria?
6. Draw a picture of a bacteria cell and label the parts.
7. What are capsules?
8. What is the main purpose of flagella?
9. What are spores?
10. What is a bacterial colony?
11. List some terms used in describing colonial morphology.
12. What is the most important stain employed in bacteriology?
13. How do Gram-positive organisms stain?
14. How do Gram-negative organisms stain?
15. What are materials used for cultivating bacteria called?
16. What is a mixed culture?
17. Normally, will a clinical specimen contain more than one type of bacteria?
18. What is a pure culture?

---

19. What is a colony?

20. At what temperature do we normally incubate cultures?

21. Explain in detail the procedure for inoculating media.

22. Draw a diagram of a properly inoculated petri dish.

23. Normally, what is the incubation period for most bacteria?

24. Describe some of the characteristics to look for when examining cultures.

EM-7 MICROBIOLOGICAL METHODS
PACKET #11 - CSC #8605 - HOW TO STREAK NUTRIENT AGAR PLATES
END OF PACKET QUIZ.

---

1. *Why are the areas of dilution drawn on the bottom of the agar plates?*

2. *When streaking the plate, the cover is not completely removed. Why?*

3. *When streaking area "A" if the loop touches any other area, will this affect the final result?*

4. *After streaking area "A" you flame the loop. Is it necessary to flame the loop after streaking area "B"?*

5. *After 24 hours of incubation, an agar plate showed heavy growth in area "A", continuous growth in are "B", but no growth in areas "C" or "D". Exlain what might have gone wrong.*

6. *A second plate, streaked with the same bacterial culture as in 5, showed heavy growth in areas A, B, and C, and continuous growth in D. What do you think may have happened?*

7. *A third plate in the same group showed no growth in any area of the plate. Explain what you think might have caused this.*

LIST THE LETTERS OF THE FOLLOWING STATEMENTS IN CORRECT ORDER FOR STREAKING NUTRIENT AGAR PLATES TO ISOLATE BACTERIAL COLONIES.

A. *Streak the loop in a zigzag manner over the area marked "A".*

B. *Mark the bottom of a sterile agar plate with the letters "A", "B", "C" and "D".*

C. *Reflame the loop, touch the streaked "A" and in a zigzag manner, streak the area marked "B".*

D. *Incubate the agar plate at 37 degrees C for 18-24 hours.*

E. *Examine the agar plate for isolated colonies of bacteria.*

F. *Clean the work area with an approved disinfectant.*

G. Continue the streaking procedure for area "C" and "D".

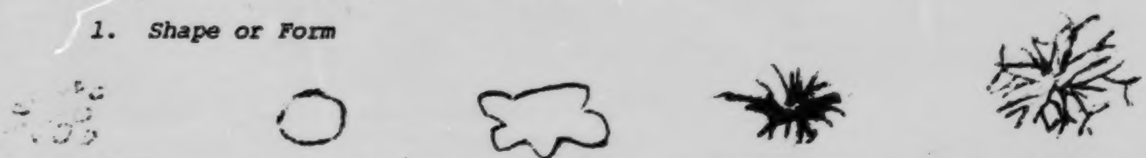
H. Flame an inoculating loop and transfer one loop of bacterial culture solution to area "A" of the agar plate.

EM-7 MICROBIOLOGICAL METHODS
END OF MODULE TEST

This test is a practical one. You are to obtain a sample of soil, compost, water or other material. Use a 10 gram sample to obtain a count of total bacteria. Remember to also find percent moisture in order to reduce final count to dry-mass basis! From one of the plates which have a low colony count collect a sample and purify using good technique. Produce a good slant of your isolate and several good slides, utilizing whatever staining technique is required. You may maintain the culture in the refrigerator for the advanced bacteriology or fungi modules. Show your dilution plates (5) and your slant to the instructor for grading.

CHARACTERISTICS TO NOTE WHEN DESCRIBING COLONIES:

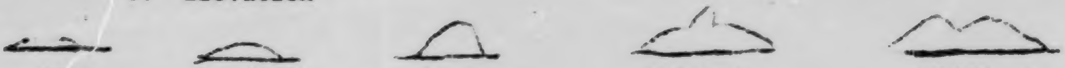
1. Shape or Form



Punctiform   Circular   Irregular (Ameboid)   Filamentous   Rhizoid

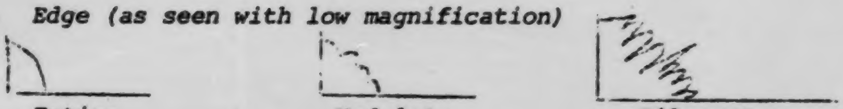
2. Surface - smooth, rough, mucoid, dry

3. Elevation



Flat   Raised   Convex   Unbonate   Umbilicate

4. Edge (as seen with low magnification)



Entire   Undulate   Filamentous

5. Size

6. Pigment - color derived from carotenoids, anthocyanins, melanins, maphthaquinones, and pyrolle and phenazine derivatives.

7. Opacity - transparent colonies transmit all light
opaque colonies transmit no light
translucent colonies transmit partial light

USES OF GRAM-STAIN REACTION:

1. Visualizes and differentiates between organisms

2. Demonstrates morphology of organism

3. Useful in presumptive identification (Serological, biochemical and other tests must be run before identification is possible.)

GENERAL RULES CONCERNING BACTERIAL MORPHOLOGY AND GRAM-STAIN REACTIONS:

1. Cultures should be less than 24 hr. old.

2. Reasons for failure to stain positively are age of culture, low pH of medium or both.

3. True gram-negative organisms will not become gram-positive, although increasing alkalinity may make them appear to change.

4. Increase in acidity may cause gram-positive organisms to appear gram-negative.

5. Most cocci are gram-positive (Neisseria is an exception) and non-motile.

6. Rods of the genera Bacillus and Clostridium form spores.

7. Other genera are rarely sporeformers.

8. Descriptions should always include experimental conditions because colony characteristics, organism size, and type of growth in liquid media vary, depending upon type of medium used, environmental conditions, age of culture, etc.

GENERAL INFORMATION ON DYES AND STAINS:

1. Staining - artificially producing color in microorganisms to see microscopically.

2. Dyes-organic compounds containing benzene rings with attached chromophore and auxochrome groups. Majority of dyes are salts in which colored anions or cations resonate among structures differing widely in electrical charge distribution. May be classified on basis of method of application or basis of structure.

3. Mordants - fix stain so that it will be retained by materials being stained.

EXAMPLES: iodine, ferrous sulfate, tannic acid.

4. Types of Stains:

   A. selective - for specific structure or material.

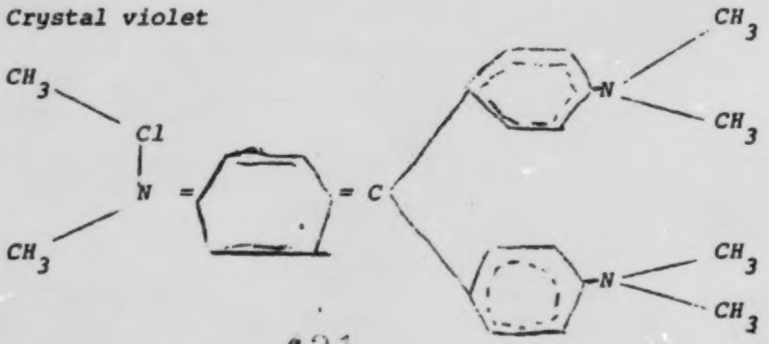
   B. Differential - differentially stain with two colors or stain one type of organism but not another.

   C. Direct - actually add color to organisms.

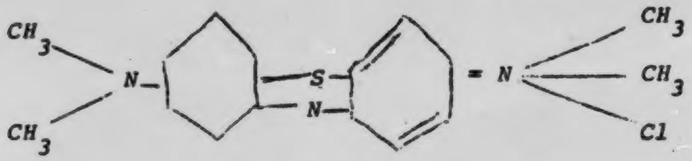
   D. Indirect - stain background so that organism can be seen by contrast.

5. Structures:

   A. Crystal violet



B. Methylene blue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EN-7 MICROBIOLOGICAL METHODS
PACKET #12 GRAM STAINING AND MORPHOLOGICAL STUDIES

MATERIALS:

1. *Cultures and agar plates of Staphylococcus aureus, Escherichia coli and other assigned microbes.*

2. *Media, nutrient agar plates, tube of nutrient broth.*

3. *Solutions - Gram's stain solutions.*

4. *Microscope slides.*

5. *Microscope with oil-immersion lens.*

PROCEDURE:

A. *Colony morphology*

1. *Describe five colonies with different morphologies isolated by streaking. Circle and number with wax pencil on back of plate.*

2. *Touch loop to colony and transfer organisms to a small drop of water on a labeled slide. If area on slide that contains organisms is circled on back of slide with wax pencil, organisms may be located more readily after staining. Make slides from all colonies selected. Don't make smears too thick!*

3. *Prepare control slide in the same manner, utilizing known gram-positive and gram-negative organisms. Both controls on the same slide serve as a check on stains and technique.*

4. *Allow slide to dry. Fix by passing back of slide through a flame several times. Back of slide should feel warm, not hot, to the touch.*

5. *Gram's Staining Procedure*

   A. *Flood smear with crystal violet solution. Let stand for one minute. It is not necessary to cover the entire slide. Just use enough stain to cover bacterial film.*

   B. *Wash slide in tap water.*

   C. *Flood slide with Gram's iodine solution. Let stand for two minutes.*

   D. *Hold slide vertically and de-stain by adding acetone-alcohol drop by drop until purple color no longer comes out of the thin areas of the smear. (10-20 seconds)*

   E. *Wash slide in tap water.*

F. Counterstain by covering slide with safranine solution for 30-60 seconds.

G. Wash in tap water and drain slide. Clean back of slide, stand it on end, and allow to air dry.

6. Observe slides with oil-immersion lens. (See sheet on How to use the Oil Immersion Lens)

7. Note shape, relative size, cell arrangement or grouping, and Gram-stain reaction. Add this information to morphological description of colony. Show your control slide to the instructor.

8. At least one colony will probably be a sporeforming organism. Streak organisms from this colony to a nutrient agar plate. Use the same technique used to isolate colonies from a previous laboratory.

9. Invert plate and incubate at room temperature. Check after 24 to 48 hours. If not a pure culture, pick an isolated colony and streak to another nutrient agar plate.

10. Inoculate a tube of nutrient broth from this pure culture. Incubate at 37°C. This culture will be used in the following laboratories.

COUNTING MICROORGANISMS

Once an organism (e.g. bacteria, actinomycete, protozoan, myxomycete, algae) has been isolated from the environment (soil, sludge, infection, industrial product) and if an estimate of quantity is required then a count of colonies must be made. Of course one of the methods of dilution must have have been utilized in order to calculate organisms/mass dry sample when the count has been performed.

ISOLATION PROCEDURES

1. Decimal dilution pour plate
2. Spread Plate technique (hockey stick)
3. Streaking
4. Aerosis

SELECTIVE PROCEDURES

1. Differential agar media
2. Differential solid media
3. Differential liquid media
4. Environment manipulation

MAINTENANCE OF TUBES OF CULTURE

1. Periodic changes to fresh media, with maintenance at specific temperature in interim. Screw-capped tubes preferred.
2. Overlay culture on agar slant with sterile mineral oil. Many cultures may thus be stored for months at room temperature without necessity of transferring.
3. Lyophilization - organism grown on nutrient media are washed and suspended in sterile skim milk or heat-inactivated serum. Small quantities of this suspension are quick-frozen in a dry ice-acetone mixture at -60 to -65 C and dried for 5-6 hours under a vacuum. Sealed tubes are then stored, preferably at low temperatures in the dark.
4. American Type Culture collection, Wash. D.C., maintains standard cultures, which may be ordered.
5. Dry-ice storage in special containers at -75C for over a year will not result in a loss of viability.

COUNTING MICROORGANISMS ON PLATES

1. Direct measurements

    A. Use of Petroff-Hausser bacteria counter to determine number of cells.

    B. Determination of cell mass weight or by nitrogen or protein determinations.

2. Indirect measurements

    A. Plate counts to determine number of organisms (Quebec Counter)

    B. Determination of cell mass by turbidimetric measurements (nephelometer)

EM-8 SLIME MOLDS

PURPOSE:

To introduce the student to the"of't-times"neglected slime molds, creatures which seem part animal and part fungus.

MATERIALS:

1. *Ashworth, J. and J. Dee. THE BIOLOGY OF SLIME MOLDS. Crane-Russak Co.*
2. *Bonner, J.T. THE CELLULAR SLIME MOLDS. Princeton Univ. Press.*
3. *Crowder, W. MARVELS OF MYCETOZOA. Nat'l. Geographic Mag. 49, (1926).*
4. *Jaffe, L.F. MONPHOGENESIS IN LOWER PLANTS. Ann. Rev. Plant Physiology 9: 359-384.*
5. *Martin, G.W. and Alexopoulos, C.J. THE MXYOMYCETES. University of Iowa Press.*
6. *Raper, K.B. ISOLATION, CULTIVATION AND CONSERVATION OF SIMPLE SLIME MOLDS. The Quarterly Review of Biology 26: 169-190.*
7. *Singh, B.N. STUDIES ON SOIL ACRASIEAE. J. of Gen. Micro. 11: 361-67.*
8. *Singh, B.N. SELECTIVITY IN BACTERIAL FOOD BY SOIL AMOEBAE IN PURE MIXED CULTURE AND IN STERILIZED SOIL. Annals of Applied Biology 28: 52-64.*
9. *Singh, B.N. MYXOBACTERIA IN SOILS AND COMPOSTS: THEIR DISTRIBUTION, NUMBER AND LYTIC ACTION ON BACTERIA. J. of Gen. Micro. 1 (1).*
10. *Sussman, M. THE DEVELOPMENTAL PHYSIOLOGY OF THE AMOEBOID SLIME MOLDS. Biochem. & Physiol. of the protozoa 2: 201-223.*
11. *Thom, C. and Raper, K.B. MYXAMOEBAE IN SOIL AND DECOMPOSING CROP RESIDUES. J. Wash. Acad. Sci. 20: 362-370.*
12. *Wenrich, D.H. SEX IN PROTOZOA: A COMPARATIVE REVIEW. AAAS Wash. D.C.*
13. *Wenrich, D.H. SEX IN MICROORGANISMS: A COMPARATIVE REVIEW. AAAS. Wash. D.C.*
14. *Wilson, D.M. SEXUALITY IN THE ACRASIALES. Proc. Nat. Acad. Sci. 38: 658-662.*
15. *Zahl, P. BIZARRE WORLD OF FUNGI. Nat'l. Geographic Mag. 1965. Vol. 128 (4).*
16. *Slime Mold Slide Kit - Carolina Biological Supply Company*
    Burlington, North Carolina 27215

Dried samples of slime molds may be locally acquired or purchased.

EM-8 SLIME MOLDS

OBJECTIVES: To enable the student to:

1. Understand the life cycle of typical slime molds.
2. Differentiate taxonomically important morphological and microscopic characteristics of slime molds.
3. Isolate slime molds from a field sample.
4. Cultivate slime mold isolates
5. Preserve slime molds on slants or as dried specimens
6. Identify slime molds.

DATE STARTED: ____________________

EM-8 SLIME MOLDS INSTRUCTION AND CHECKOFF LIST

PACKET #1 - Read Ashworth and Dee's THE BIOLOGY OF SLIME MOLDS. You may have difficulty with some of the chemical and technical terms if your previous background has not included biology and chemistry. DO NOT LET THIS STOP YOU ... Read a chapter a day and take notes. Be sure to place major scientists, their contributions, terms and chemicals on 3" x 5" cards. Place references which you could find in U.S. libraries in your DATA STORAGE SYSTEM. It is not necessary to include French, Russian, or German titles (UNLESS you can read these languages) in DATA STORAGE.

Figures 1-1 and 5-1 belong in your F.I.D. notebook on the facing page for Myxomycetes.

The Appendix contains the information you might need to collect, grow, and store slime molds. This material is extracted and added to the TECHNIQUE section of your F.I.D. notebook.

UTILIZE PLANT FAMILIES to place these plants in the proper position in the F.I.D. notebook.

After reading this small book utilize the programmed review to test your recall and understanding of this booklet. Submit requested materials to your instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2 - Read Raper's ISOLATION, CULTIVATION AND CONSERVATION OF SIMPLE SLIME MOLDS. Add important scientists, vocabulary and F.I.D. materials to your files. Then after reading and taking notes, request the programmed review. Submit the materials assigned to your instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3 - Read Singh's STUDIES ON SOIL ACRASIEAE. Take notes as above and request programmed review. Submit any materials assigned in programmed review to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4 - If you have not read Singh's MXYOBACTERIA IN SOILS AND COMPOSTS IN DATA STORAGE...do so now. Data Storage cards should be prepared on new authors. Submit cards to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

EM-8 SLIME MOLDS
INSTRUCTION AND CHECKOFF LIST (cont.)

PACKET #5 - UTILIZE the methods you have learned to collect, cultivate, and describe a mxyomycete from the environment. Submit the F.I.D. sheets, the preserved slime mold, and your notes on the isolation of this creature. If weather does not permit capturing a creature, you may request one. You may use the accompanying kit to practice with these creatures, but return the dried slime molds to be recycled.

*DATE COMPLETED:*____________________
*INSTRUCTOR SIGNATURE:*____________________

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*REQUEST END OF MODULE TEST*____________________

*DATE COMPLETED:*____________________
*INSTRUCTOR SIGNATURE:*____________________

EM-8 SLIME MOLDS

PACKET #1 PROGRAMMED REVIEW - ASHWORTH & LEE - THE BIOLOGY OF SLIME MOLDS

1. Mycologists study slime molds because they are just plain interesting to people who enjoy studying fungi but an environmental scientist finds slime molds useful for understanding ______________ plant life. They feed on dead matter in soils and ______________ and many feed upon _____________. Only a few slime molds are pathogenic to plants.	
2. Can you sketch the life cycle of an acellular myxomycete and label the parts?	1. higher composts bacteria
3. Using your F.I.D. notebook sketch the life cycle of a cellular slime mold such as Dictyostelium discoideum.	2. consult your F.I.D. notebook
4. The Mysomycete, Physarum polycephalum displays one of the most interesting processes known to biology, protoplasmic __________________. This process ________ completely understood. It is known that the complex proteins ____________ and ___________ are involved; these substances are involved in human ______________.	3. Submit this sheet and any other new kritters mentioned in book to instructor at end of packet for credit.
5. M. J. Carlile found that plasmodia are ______________, that is they respond to chemical gradients and move toward certain ________________. But, plasmodia do not move toward all biochemicals.	4. streaming is not actin myosin muscles
6. Plasmodia from the same center of growth _________________ fuse. Plasmodia from different species or different isolates of the same species ______________ fuse.	5. chemotaxic biochemicals
	6. will will not

7. In or near the endoplasm are found ______________ which are involved in ____________ streaming. The ectoplasm is composed of a colloidal ______________ while the endoplasm is termed a ________________.	
8. Who first studied mitosis in slime molds? Where is this work now continued by Dr. H.P. Rusch?	7. fibrils protoplasmic plasmagel plasmasol
9. In culture Physarum grows ______________, doubling its growth every ten hours. Dr. C.J. Alexopoulus of Univ. of Texas has divided myxomycetes into __________ Orders; three of which contain few species. There are about ____________ species known, but only _________ of these have been studied in culture.	8. Howard, 1932 McArdle Lab for Cancer Research in Wisc.
10. Members of the order ___________ are the most common in the lab and in the field. Genera in this order include: __________, ____________, __________, ____________, and Physarum.	9. logarithmically six 500 50-60
11. When a slime mold is to sporulate it first forms __________. Then a __________ forms, which gradually fills with non-living grains. Then the head of a _____________ forms covered with a continuous coating, the ____________. Within a non-living framework, the _______ intermingles with spores.	10. Physarales Didymium Physarella Badhamia Fuliga
12. One monograph famous for its illustrations of acellular slime molds is ______________ by A. Listor (1925). Is it in your DATA STORAGE?	11. papillae stalk sporangium peridium capillitium
	12. A Monograph of the Mycetozoa, Oxford Univ. Press

13. W. D. Gray (1938) and others since found that the following are often necessary for sporulation (a) __________, (b) ___________ (c) ______________ and (d) ______________. While plasmodia grows (e) ______________ under bark, leaves, or soil; (f) ________________ bodies are found (g) ____________ on surfaces.	
14. Spores when they germinate in water form ________. These swim by means of _____________ and eat by gathering bacterial food with ________________. It is difficult or (so far) impossible to grow these amoeba in _________ media. They feed upon live or dead _____________. On culture media in a __________ dish the amoeboid cells aggregate to form ___________. Colonies derived from a single cell do not usually form plasmodia. If amoeba of different sexes or mating-type contact one another then ____ ________ develop and they have a ____________ life cycle.	13. a. light [illegible]. starvation c. cold d. drought e. hidden (protected) f. fruiting g. exposed
15. Plasmodia are ____________ while ___________ are uninucleate. In plasmodic nuclear division occurs ___________ cell division and mitosis occurs without destruction of the ______________ membrane. In amoeba the cell membrane __________ ___________ during mitosis. Plasmodia can synthesize most of their ______________ substances, while _____________ have to feed as _______________ or parasites.	14. amoebas flagella pseudopodia artificial bacteria Petri plasmodia plasmodia heterothallic
16. CELLULAR SLIME MOLDS: These slime molds have an ______________ stage when they feed upon bacteria and when food runs low they form an aggregate stage called a _____________. This form ___________ toward a higher __________ and _____________. Finally a __________ body forms. The ________ from the fruiting body germinate as ________ and the cycle is complete.	15 multinucleate amoeba without nuclear breaks down (disintegrate) growth amoeba saprophytes
	16. amoeboid grex moves (migrates) moisture temperature fruiting spores amoeba

17. The Dictyostalia are divided into ____________ families by Ainsworth & Dee. These are the _________ and the ______________. The species A_______________ leptosum is the only member of its genus in the Acytomtelidae. The information on this creature should be on a kritter sheet. There are three ________________ in the Dictyostellidae....These should be on kritter sheets (pg. 36-38). One other group of cellular slime molds is the Acrasia composed of ______________ families, the Guttulinopsidae and the rose colored ____________. These slime molds are common on plants locally.	
18. Place Fig. 6.1 Types of aggregation amongst Dictyostellidae in the kritter notebook. You are not responsible for detail on pages 46-62.	17. two Dictyostellidae Acytostelidae Acytostelium genera two sappinidae
	18. Hand in to instructor for credit.

EM-8 SLIME MOLDS
PACKET #3 SINGH - "STUDIES ON SOIL ACRASIEAE" - JOURNAL OF GENERAL MICROBIOLOGY
PROGRAMMED REVIEW

1. What two species of Acrasieae were utilized in these studies? Are they in your F.I.D. notebook?	
2. How was a bacterial lawn produced by Singh?	1. Dictyostelium mucoroides (Brefeld (1869) Distyostelium giganteum (Singh, 1947)
3. When are myxamoebae most voracious in eating bacteria? When do they stop feeding? Which slime mold was most destructive of bacteria?	2. 2-3 loopfuls of 2-3 day old culture of bacterium from nutrient agar was spread on non-nutrient agar (1.5% agar, 0.5% NaCl, pH 6. 5-6.8). A spore mass (sorus) was punctured with a sterile needle and transferred to the bacterial lawn.
4. Did drying of the soil encourage fruiting of Dictyostelium spp.? Is moisture necessary for germination of spores?	3. during the intensive reproductive stage. they stop feeding when they rpoduce pseudoplasmodia. Dictyostelium mucoroides-which likes soil environment was most active.
5. Who in 1938 discovered slime molds in micropedological studies but thought the stalks were fruiting bodies of fungi?	4. No..spread and fruiting increased with increased soil moisture. Moisture is necessary for germination of spores.
	5. Kubiena and his colleagues at the Univ. of Iowa in 1938. They could not grow slime molds on fungi media!

EM-8 SLIME MOLDS
PACKET #3 SINGH - "STUDIES ON SOIL ACRASIEAE"
PROGRAMMED REVIEW (cont.)

6. What is the rate at which slime molds spread through the soil?	
7. Who found that Rhisobium spp. spread at about the same rate?	6. one inch in 24 hours
8. Just as Beltsville, Maryland is the home of the U.S.D.A. experimental area, ______________ is the British agricultural experiment station.	7. Thornton, H.G. & N. Gangulee - "The Life Cycle of the Nodule Organism Bacillus radicicola (Beij,) in Soil and its Relation to the Infection of the Host Plant". - Proc. Royal Soc. of Britain B. 99, 427
9. At 10% moisture were myxamoeba fruiting bodies formed? What happened at 40$?	8. Rothamsted
10. The mxyamoeba tested showed definite likes and dislikes in their feeding habits. This is called ______________ feeding effect.	9. No. Many fruiting bodies at 40$.
	10. differential

EM-8 SLIME MOLDS
END OF MODULE TEST

MATCHING:

1. _____ Myxomycetes
2. _____ plasmodium
3. _____ hypothallus
4. _____ peridium
5. _____ sclerotia
6. _____ capillitium
7. _____ acrasin
8. _____ psuedoplasmodium
9. _____ sorocarp
10. _____ spherules

A. aggregation secretion
B. the base of sporangia, free of detritus, firm and structurally sound
C. vegetative phase of a myxomycete
D. made up of dormant plasmodia ready to sporulate
E. segments of sclerotia
F. plasmodial slime molds
G. colonial unit of aggregation amoebae
H. fruiting structure
I. the outer firm structure of the hypothallus
J. threads which give sporangium structure

CLASSIFICATION: *GIVE FAMILY AND ORDER*

	FAMILY	*ORDER*
Physarum	________________	________________
Stemonitis	________________	________________
Lycogala	________________	________________
Trichia	________________	________________
Dictyostelium	________________	________________

There are two major forms of slime molds: The Myxomycetes and the Acrasiomycetes. Explain how they are significantly alike and yet quite different.

In what way is the nutrition of Myxomycetes unlike that of fungi?

Choose one slime mold you have researched quite well and discuss with kritter sheets. Utilize both sides of the sheet and include isolation, culture and preservation notes.

EM-9 FUNGI

PURPOSE:

To aid the student in understanding the identification, taxonomy, ecology, morphology, pathology and culture of the fungi.

MATERIALS:

1. *Ainsworth, G. C., and Bisby, G. R. 1961. A dictionary of the fungi. 5th edition, Commonwealth Mycological Institute, Kew, Surrey, England. REFERENCE*

2. *Barghoorn, E. S., and Linder, D. H. 1944. Marine Fungi: Their Taxonomy and Biology. Farlowia 1:395-467.*

3. *Barnett, H. L. and Hunter, B. B. 1972. Illustrated Genera of Imperfect Fungi. 3rd Ed. Burgess Publishing Company, Minneapolis, Minnesota. p. 241.*

4. *Barron, G. L. 1968. The Genera of Hyphomycetes from Soil. The Williams & Wilkins Co., Baltimore. p. 364.*

5. *Bender, H. B. 1934. The Fungi Imperfecti: Order Sphaeropsidales. With Keys and References for the Genera. Published by the author.*

6. *Bessey, E. A. 1950. Morphology and Taxonomy of Fungi. The Blakiston Company, Philadelphia.*

7. *Cain, R. F. 1952. Studies of Fungi Imperfecti. I. Phialophora. Can. J. Bot. 30:338-343.*

8. *Cooke, R.C. and Godfrey, B. E. S. 1964. A Key to the Nematode-Destroying Fungi. Trans. Brit. Mycol. Soc. 47:61-74.*

9. *Cooney, D. G. and Emerson, R. 1964. Thermophilic Fungi. W. H. Freeman and Co., San Francisco. p. 188.*

10. *Funder, S. Practical Mycology, Hafner Publishing Co., Inc., N. Y. p. 146. MAIN TEXT*

11. *Gilman, J. C. 1957. A Manual of Soil Fungi. 2nd Ed. Iowa State College Press, Ames, Iowa. REFERENCE*

12. *Hughes, S. J. 1959. Starting Point of Nomenclature of Hyphomycetes. Taxon 8L89-103.*

13. *Lodder, J. and Kreger-Van Rij, N. J. W. The Yeasts - A Taxonomic Study, Interscience Pub., N. Y. REFERENCE*

14. *Peterson, R, H. 1962. Aquatic Hyphomycetes from North America I. Aleuriosporae (Part 10 and key to genera.) Mycologia 54:117-151*

EM-9 FUNGI

__MATERIALS__: (cont.)

15. Petersen, R. H. 1963. Aquatic Hyphomycetes from North America II. Aleuriosporae (Part II) and Blastosporae. Mycologia 55:18-29.

16. Raper, K. E. and Fennell, D. I. 1965 The Genus __Aspergillus__. The Williams and Wilkins Co., Baltimore. p. 686

17. Raper, K. B. and Thom, C. 1949. A Manual of the Penicillia. The Williams and Wilkins Co, Baltimore.

18. Smith, H. V. and Smith, A.H. 1973. The Non-Gilled Fleshy Fungi. Wm. C. Brown Co., Dubuque, Iowa. p. 402

19. Thom, C. and Raper. 1945. A Manual of the Aspergilli. The Williams and Wilkins Co., Baltimore.

20. Waksman, S. A. 1917. Is There Any Fungus Flora of the Soil? Soil Science 3:565-589.

21. Wang, C. J. K. 1965. Fungi of Pulp and Paper. N. Y. S. U. Col. of Forestry Tech. Publ. 87.

22. Wolf, F. A. and Wolf, F. T. 1947. The Fungi. Vol. 1. John Wiley & Sons, N Y.

__OBJECTIVES__: To enable the student to

1. *Identify fungal morphological structures.*
2. *Understand fungal taxonomy.*
3. *Collect fungal samples from the terrestrial environment.*
4. *Count fungal colonies.*
5. *Identify unknown suscepts at least to genus.*
6. *Store properly either large fungi or slants of microscopic fungi.*

DATE STARTED: ______________________

EM-9 FUNGI INSTRUCTION AND CHECK OFF SHEET

Bergey's Manual covers all the bacteria known and there are similar manuals for Slime Molds, Green Algae and Yeasts, but there is no one manual which handles all the fungi in such detail.

There are so many species, 100,000 or so, and more are being discovered all the time. They cover a range of sizes from tiny yeasts, verging upon bacterial size, to giant puffballs and bracket fungi. The yeasts which make our beer, the mushrooms for our steaks, the penicillin for curing our diseases, the molds that eat our food and rot our shoes are all members of the giant phylum (or division) FUNGI.

Funder's Manual, *Practical Mycology*, was chosen to give the student an over-view of some of the important common fungi. Many other references are equally useful.

PACKET #1 - Funder, S. *Practical Mycolpgy: A Manual for Identification*. Read pages 3-24. Produce Data Storage Cards for major references. Produce supplemental drawings of all figures from pages 13-24. These drawings should be placed in your Field Identification Notebook. View the prepared slides of typical fungus structures. Utilize the programmed review.

DATE COMPLETED: ______________________
DATA STORAGE CARDS: ______________________
F.I.D. DRAWINGS: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #2 - Read pages 25-29 in Funder. Produce charts. Read pages 240-255 in Muller's, *Botany: A Functional Approach*.

DATE COMPLETED: ______________________
PHYCOMYCETES: ______________________
ASCOMYALES: ______________________
DEUTEROMYCETES: ______________________
BASIDIOMYCETES: ______________________
STRUCTURES OF FUNGI
IMPERFECTI: ______________________
DATA STORAGE CARD: ______________________
INSTRUCTOR SIGNATURE: ______________________

PACKET #3 - Waksman, S. A. "Is There any Fungus Flora in the Soil?" Read this article from Soil Science and utilize the programmed review.

DATE COMPLETED: ______________________
F.I.D. SHEETS: ______________________
INSTRUCTOR SIGNATURE: ______________________

EM-9 FUNGI
INSTRUCTION AND CHECK OFF SHEET (cont.)

PACKET #4 - CAPTURING SOIL, COMPOST, OR SLUDGE FUNGI.
Read pages 30-37 in Funder; Utilize the handout - SOIL FUNGI. Using a sample of your own choice count the fungi colonies found in a gram of dry sample. Streak several interesting colonies onto separate Saboraud agar slants for PACKET #5.

DATE COMPLETED: ____________________
FUNGAL COLONY COUNT: ________________
INSTRUCTOR SIGNATURE: _______________

PACKET #5 - Utilize Funder, Gilman or Wolf & Wolf, or any other reference required to identify five fungi preferably of widely differing morphology. At this point you will need instructor guidance. Produce complete 'kritter' sheets' on these 'separates'.

DATE COMPLETED: ____________________
KRITTER SHEETS: ____________________
INSTRUCTOR SIGNATURE: _______________

PACKET #6 - Smith, H. V. and Smith, A. H. The Non-gilled Fleshy Fungi. Read this short book and after reading utilize the programmed review.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: _______________

PACKET #7 - IDENTIFICATION OF FUNGI
Utilize any of the keys available to identify five large fungi. They may be gilled or non-gilled.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: _________________

REQUEST END OF MODULE TEST

END OF MODULE TEST: ________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: _______________

EM-9 FUNGI
PACKET #1 - PROGRAMMED REVIEW

1. Actinomycetes are included in Funder's Manual even though they are now classified as __________________. *Nocardia* and *Streptomyces* are ____________. Yeasts are included in this manual because they are _________. The diseases caused by fungi are called ______________ ______________.	
2. Fungi reproduce by ________________. When a spore germinates it first sends out a ___________; this develops into a ________________ . Some fungi develop cross-walls in the hyphae called __________. When there are no septa the protoplasm flows without interruption through the filament and is said to be ______________________________.	1. bacteria actinomycetes,(also bacteria) fungi mycoses
3. The Basidiomycetes form special outgrowths at septa called ____________________. When there are many intertwined hyphae the structure is called a _______________. The spore producing structure is called a _________________, at the end of which is the rounded _______________. Inside the sporangium is the _____________ and many ____________________. Some fungi produce flagellated spores called ______________; their sporophores are termed _________________________.	2. spores germ tube hypha(e) septa coenocytic
4. Not all fungi bear spores in a rounded container (sporangium); some spores are born free. This type of sporophore is termed a _______________. The spores are called _______________. Sometimes the conidial chains are attached to the vesicle by flask-shaped ____________________. If the conidiospores break off and remain in chains they are called ________________________.	3. clamps mycelium sporophore sporangium columnella sporangiospores zoospores zoosporangia
5. Some fungal genera form two types of conidia; one large and several to many called the ___________, and spherical, pyriform, oval or clavate smaller conidia called _______________. Macroconidia divided by both transverse and longitudinal septa are termed __________. Some fungi form very large complex fruiting structures called _________. When a large mass of spores are born in a circular area under a cover the structure is called a _____________________.	4. conidiophore conidia phialides catenulate
	5. macroconidia microconidia muriform coremia (or synnema) sorus

---

6. An erumpent cushionlike flat mass of hyphae having conidiophores exposed is termed an ________________. Similar to the acervulus, but more compact resting on a stroma is the structure ______________. If the spore-bearing structure is buried in host tissue with a small opening (ostiole) it is a __________________.

---

7. In yeasts the budding reproduction cells are called ____________________. In some yeasts filaments protrude from the parent cell which show by constrictions that they really are 'unseparated' buds; these structures are not mycelia or hyphae, but are similar. They are called ________-______________ or _______________. Thallospores which are converted into thick-walled resting spores are called __________________. If barrel-shaped resting spores are produced from segmentation of the hyphae they are called __________________________.

6. acervulus
sporodochium
pycnidium

---

8. Sexual reproduction and the structures and spores which result therefrom ______________ encountered often when fungi are cultivated on ordinary media. Female structures are called _____________ and male structures __________________________. The oöspores are contained in __________________.

7. blastospores
pseudomycelia
pseudohyphae
chlamydospores
arthrospores

---

9. Fusion of hyphal tips produce _________________, large thick-walled bodies in which sexually produced spores develop. When sexual spores develop in a sac known as an _______________, the spores resulting are called _________________. Ascospores usually number _________________. There are several morphological forms of asci, the spherical or flask-shaped with a narrow neck (the ostiole) called the _______________ and the open saucer or cup-shaped structure, the ______________________.

8. are not
oögonia
antheridia
oöspheres

---

10. The Basidiomycetes, usually have club-shaped structures called _____________, from which four ______________ develop. Sometimes a supporting structure develops between basidiospores and the basidium called a ____________________.

9. zygospores
ascus
ascospores
eight
perithecium
apothecium

---

10. basidia
basidiospores
sterigma

EM-9 FUNGI
PACKET #2

Read pages 25-29 in Funder. Prepare cover sheets for Myxomycetes, Ascomycetes, Basidiomycetes, Deuteromycetes (Fungi Imperfecti), Phycomycetes. Utilize the fold-out on page 127 to show the breakdown to genus of these groups. Use a full 8½"x 11" paper to show these breakdowns. The Phycomycetes will include general 1 through 23, Ascomycetes 24-41; Deuteromycetes 42-106; Basidiomycetes 107-122. Include further notation from Funder, Gilman, Wolf and Wolf, and/or other texts to aid in your chart making. Produce another chart for the Structures of Fungi Imperfecti to include the information on pages 28 & 29.

HAND IN YOUR ARTISTICALLY ARRANGED, NEAT, SMUDGELESS FINAL PRODUCTS FOR YOUR INSTRUCTOR'S APPROVAL.

EM-9 FUNGI
PACKET #3 - PROGRAMMED REVIEW
"IS THERE ANY FUNGUS FLORA OF THE SOIL?"

1. Two important functions of soil fungi known in 1917 were ________________ decomposition and ______________________.	
2. The major question asked in this study is?	1. cellulose ammonification
3. Adametz (and later Goddard) studied the problem of change in soil fungus population with _______________. He found ____ _________. Hagem in Norway found that _______________ of cultivated soil differed from those of ______________ soils. Manns & Beckwith in 'flax-sick' soils found abundant ____________. Jensen stressed that plant ______________ fungi may over-winter as soil _____________.	2. Do soils from different geological areas have SIMILAR organisms?
4. It was Goddard who first suggested that there is a ________________ fungus flora in the soil, regardless of ___________ or ____________. This concept was confirmed by the studies of ___________ in Texas.	3. depth no change Mucorales forest Fusaria parasitic saprophytes
5. The most widely spread groups of fungi are the: ______________, _______________, _______________, ______________, _______________, _______________, and ______________. NOTE: Not all of these occurred in every sample.	4. constant tillage manuring Werkenthin
6. The largest number of species of soil fungi belong to one of the divisions of ________________________. Most soil fungi belong to the family _______________, in the class ______________.	5. Mucors Aspergilli Penicilli Trichodermae Rhizopuses Cephalosporia Fusaria
	6. Fungi Imperfecti (Deuteromycetes) Mucedenaceae Hyphomycetes

7. Most soils contain many representatives of two soil genera in the Hypomycetes, the genera ______________ and ________________. In some soils more members of ________________ or of ______________ outnumber the Aspergilli and Penicilli.

8. The most common genera of fungi isolated from different soils are Penicillum, Mucor, Aspergillus, Trichoderma, Fusarium, Cephalosporium, ___________, ___________, ______________, ________________, ___________, and _____________. THESE FUNGI REQUIRE A KRITTER SHEET IN YOUR FIELD IDENTIFICATION NOTEBOOK.

7. Aspergillus
Penicillium
Mucorales
Trichodermae

9. The data presented in this paper tend to prove that _________ are true soil organisms. The fact that the genera found by Waksman are found all over the world shows that these fungi are __________. More fertile soils contain ________ fungi.

8. Zygorhynchus
Rhizopus
Cladosporium
Alternaria
Verticillium
Aerostolagmus

10. Different soils do have different ___________ of fungi both as individuals and as _____________, but the fungi _________ of most of the genera found in this study are apparently universally present.

9. fungi
cosmopolitan
more

10. numbers
species
spores

HAVE YOU PLACED THIS ARTICLE ON DATA STORAGE AND KEY WORD CARDS?

HAVE YOU FINISHED THE KRITTER SHEETS REQUIRED?

HAVE YOU PUT ALL NEW NAMES AND TERMS ONTO 3" x 5" INDEX CARDS?

EM-9 FUNGI
PACKET #4 - CAPTURING SOIL, COMPOST OR SLUDGE FUNGI
STUDENT HANDOUT

SOIL FUNGI

Soil fungi are always present in soil but are most prevalent in the initial stages of decomposition of plant residues. They are important in a positive way by helping to produce soil aggregates and in recycling the litter from forest, field and farm. Often they cause disease in plants, animals or man. As is so often the case some fungi attack other fungi, bacteria or higher animals and they always compete with other microbes in the soil for space and nutrients.

Fungi counting is always highly suspect. When a sample is shaken up the mycelia from ONE plant will break up and when the plates are poured each portion will grow and cause the investigator to believe there are many plants. Also, spores and other resting structures will germinate as well as young active spores. Counts are often misleading but if two soils are compared then a meaningful statement about fungal growth may be made.

Fungi produce many well known bacteriocides so that to prevent growth of bacteria and actinomycetes (which are also bacteria) a low pH and antibiotic may be helpful.

MATERIALS NEEDED:

WATER BLANKS: Using the 100 ml bottles provided prepare one bottle with about three dozen glass beads and 95 ml of distilled, deionized (d.d.) water, and seven other bottles with 90 ml of d.d. water and no beads. These may be prepared well ahead of a test run and stored. STEAM STERILIZE.

SOIL EXTRACT: For bacteria, actinomycetes, and fungi a soil extract diluent is prepared to provide a normal trace element background for future agar solutions. TO PREPARE:

1. *Mix 1 kg of local fertile soil with 1.5 liters of tap water.*
2. *Autoclave at 15 psi for 15 minutes.*
3. *After partial cooling and settling, filter the supernatant suspension using a Buchner funnel, filter aid.*
4. *If not yet clear let it stand in a refrigerator at 40°C overnight and then decant into a sterile container.*
5. *Store close to freezing point until used.*

ROSE-BENGAL STREPTO-CHLOR-AGAR: Add 20 g of agar, 1 g of KH_2PO_4, 0.5 g of $MgSO_4 \cdot 7H_2O$, 5 g of peptone, 10 g of dextrose, and 0.033 g of rose bengal to 1000 ml of soil extract. Dissolve the ingredients in the soil extract by slow boiling. Sterilize the medium in an autoclave at 15

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pounds of pressure for 15 minutes. Add the streptomycin chlortetracycline to the melted and cooled agar, just prior to its use for pouring of plates. Thoroughly mix the streptomycin solution with the agar by swirling the container. For more assured elimination of bacteria, chlortetracycline per l of medium may also be added:

__PROCEDURE:__

SAMPLING: Obtain a thoroughly mixed, gross field sample; transfer about one pint into a poly bag and transport to the lab. Store at 4°C for no more than two weeks before testing. When ready to use pass sample through sterilized 10-mesh screen, mix and remove portion of the sample for a water content determination.

IF YOU ARE TO MAKE A RUN.....START AUTOCLAVING ROSE-BENGAL STREPTO-CHLOR-AGAR NOW!

DILUTION SERIES: Transfer 10 grams of moist soil to a sterile glass-beaded water blank using waxed paper and brush. Cap. Shake vigorously for fifteen minutes,,,,__R__emove 10 ml using a sterile pipette; transfer to unbeaded water blank. This establishes a 10^{-2} *dilution. Similarly transfer from this bottle using another sterile pipette to produce* 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, *and* 10^{-7} *dilutions.*

Start with the highest dilution (10^{-7}*) and using the same 1 ml pipette transfer to three sterile petri plates samples from that dilution. Move up the series with three plates for each dilution until* 10^{-4} *dilution to obtain twelve plates (3 plates per sample). If agar is cool to touch on wrist pour between 8-10 ml into each plate by lifting covers and pouring. When all twelve plates are poured shut their covers, allow to set, and then incubate in desk drawer for two to ten days checking every day so that fast growing colonies do not cover others before a count is made. If a particular fungi is to be maintained then it must be transferred to maintainence media when the count is made, incubate and store at low temperature until identified.*

INDICATE COUNT AS FOLLOWS:

DILUTION	10^{-4}	10^{-5}	10^{-6}	10^{-7}
PLATES 1				
PLATES 2				
PLATES 3				

If plates are contaminated by bacteria or actinomycetes do not count but so indicate in records.

USING INFORMATION FROM MOISTURE DETERMINATION FIND FUNGI/GRAM DRY WEIGHT OF THE SOIL.

EM-9 FUNGI
PACKET #6 - THE NON-GILLED FLESHY FUNGI
PROGRAMMED REVIEW

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1. The fleshy fungi are those which produce a fruit body or __________ which is soft and quickly disintegrates. Gilled fungi are commonly called ________ (and are dealt with in Packet #7). Non-gilled fungi have members in classes ______________ and ________________.

---

2. The author uses a common ____________ called "Slippery Jack" which has the technical name ____________ ____________. (AT THIS POINT MAKE A KRITTER SHEET ON THIS FUNGI IF NOT ALREADY DONE DURING YOUR READING. DO YOU HAVE A DATA STORAGE CARD MADE UP FOR THIS BOOK?) The cap is called a ____________ and the stalk a ____________. Do you recall that some stalked seaweeds have 'stipes'? Unlike a mushroom which has _________ this bolete has _____________.

1. sporocarp
   mushrooms
   Ascomycetes
   Basidiomycetes

---

3. In the pores or tubes are found the __________ -producing layer, the ___________. The morphological arrangement of the ___________ determines the kind of fungus. In mushrooms it is in the form of _____________; in hedgehog fungi it forms ____________; in cup fungi it forms cup __________; in puffballs it occupies the inner ______________.

2. bolete
   Suillus luteus
   pileus
   stipe
   gills
   pores

---

4. Under the microscope the hymenium is seen to be made of a palisade layer of tiny ______________. In some species there is on the stipe a cup called a _____________ or at some distance up the stalk a ring called an _________________.

3. spore
   hymenium
   hymenophore
   gills
   branches
   spines
   linings

---

5. When you collect large fungi always note ____________ ______________, the structures near the _____________ of the stipe and soil and ____________ type. Of course season, color, moisture conditions and the _______________ are important. Collect _______ as well as mature fruit.

4. basidia
   volva
   annulus

---

5. general habitat
   base
   forest
   host
   young

6. One of your first tasks in diagnosis is to determine whether you have an Ascomycete or a Basidiomycete. Ascomycetes possess an __________, while Basidiomycetes have a distinctive __________ on which there are four __________. Spores should be drawn and labeled for __________, __________ and __________. Figure 3 shows the detail necessary for fungal identification.	
7. Another useful identification technique involves producing a __________ print. For Ascomycetes spore __________ are not essential. Measure the __________ and __________ of at least ten spores Sketch the spore in __________ view and __________ view. Note the apex and any __________. Measure wall __________. Use __________ reagent to compare colors. In some spicules called __________ are found, or immature basidia called __________ are found, or scattered cells called __________.	6. ascus basidium basidia size shape ornamentation
8. There are three kinds of cystida: __________, __________ and __________. Hyphae often appear between hymenial layers; these are __________ hyphae and form the complex __________. You might use your DATA STORAGE CARDS as the author has, but do produce KRITTER SHEETS for your F._.D. NOTEBOOK.	7. spore prints lengths width face profile markings thickness Melzer's sterigmata basidioles cystidia
9. What groups are especially difficult to further classify? What chemical is used for drying specimans? What chemicals prevent attack by insects?	8. pleurocystidia cheilocystidia caulocystidia tramal trama
	9. Ramaria Rhizopogon silica gel paradichlorobenzene & naphthalene

---

10. What are some of the chemical reagents used for detailed analysis of fungi?

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10. water
potassium hydroxide
ammonia
iron salts
cotton blue
Melzer's solution
chloral hydrate
sulfobenzaldehyde

NOW ARE YOU READY TO IDENTIFY A LARGE NON-GILLED FUNGUS? IF YOU DO NOT FEEL CONFIDENT REREAD THIS BOOK, TAKE MORE COPIOUS NOTES, AND EXPAND YOUR KRITTER SHEETS.

EM-9 FUNGI
END OF MODULE TEST

I. TECHNICAL TERMS - MATCHING:

1. _____ heterotrophic
2. _____ parasitic
3. _____ saprophytes
4. _____ ascus
5. _____ cleistothecium
6. _____ perithecium
7. _____ hymenium
8. _____ basidium
9. _____ uredinium
10. _____ heteroecious

A. heterotrophic, within or upon living organisms

B. sac-like hypha containing usually eight spores

C. globose spore structure without opening

D. flask-shaped ascocarp with ostiole

E. inner surface of apothecium of cup fungi

F. major characteristic of the Basidiomycetes

G. rust spore-bearing organ

H. dependent in their nutrition on metabolites provided by another organism

I. having two hosts

J. living upon non-living organisms or products of living organisms

II. MATCH THE COMMON NAME TO THE ORGANISM:

1. _____ corn smut
2. _____ hollyhock rust
3. _____ jelly-fungi
4. _____ puffballs
5. _____ pore fungi
6. _____ gilled fungi
7. _____ nematode-trapping fungus
8. _____ powdery mildew
9. _____ fungi imperfecti
10. _____ black bread mold

A. Tremella sp.

B. Lycoperdon sp.

C. Polyporus sp.

D. Agaricales

E. Erysiphe sp.

F. Ustilago zeae

G. Aspergillus sp.

H. Arthrobotrys connoides

I. Rhizopus stolonifer

J. Puccinia malvacearum

III. MAJOR CLASSIFICATION: PLACE THE FAMILY ORDER AND CLASS OF THE GENERA PROVIDED.

	FAMILY	ORDER	CLASS
Saprolegnia			
Agaricus			
Saccharomyces			
Lycogala			
Alternaria			

IV. CHOOSE FUNGI FROM THE GROUPS PHYCOMYCETE, BASIDIOMYCETE, ASCOMYCETE, DEUTEROMYCETE AND MYXOMYCETE AND PRODUCE FIVE KRITTER SHEETS SHOWING DETAILS OF MORPHOLOGY, STRUCTURE, IDENTIFICATION, HABITAT, LIFE CYCLE, PRESERVATION, CULTURE AND OTHER PERTINENT DATA YOU HAVE COLLECTED IN YOUR STUDIES.

EM-10 LICHENS

PURPOSE:

To introduce the special world of lichens, plants whose symbiosis puts them in a class by themselves.

MATERIALS:

Ahmadjian, V. The Lichen Symbiosis. Blaisdell

Gilbert, O. L. Further Studies on the Effects of Sulfur Dioxide on Lichens and Bryophytes. New Phytol. 69:609-628.

Hale, M. E. The Biology of Lichens. American Elsevier Pub. Co., Imc.

Hill, D. J. and Smith, D. C. Lichen Physiology XII: The 'Inhibition Technique'. New Phytol. 71:15-30.

Nearing, G. C. The Lichen Book. Eric Lundberg. Ashton, Md.

Richardson, D. H. S. Jackson Hill, and Smith, D. C. Lichen Physiology XI. New Phytol. 67:61-68.

Smith, A. L. Lichens. Cambridge Univ. Press.

Smith, D. C. The Biology of Lichen Thalli. Biol. Rev. 37:537-570.

OBJECTIVES: To enable the student to:

1. Understand the macro- and micro- structure of lichens.
2. Measure growth of lichens.
3. Identify lichens to genus.
4. Collect and preserve lichens.
5. Conduct environmental studies using lichens.

EM - 10 THE LICHENS

INSTRUCTION AND CHECK OFF SHEET
NAME: ______________________________
DATE STARTED: ______________________

BE SURE TO INSERT ONE OF THESE IN TO YOUR NOTEBOOK AND HAVE ONE PUT INTO YOUR FOLDER WHEN YOU EMBARK ON THIS TOUR INTO THE WORLD OF LICHENS.

PACKET #1:

Ideally this packet should be utilized after studying Algae and Fungi since a lichen is a symbiotic creature, a combination of a fungus which provides the algae with a small aquatic world, and an algal colony which provides the products of photosynthesis to the fungus. For this reason Chapter 5 on symbiosis is studied in Packet #2, and Chapters 9 & 10 which deal in taxonomy are considered with the accompanying handbook, How To Know Lichens. Chapters 6 through 8 are assigned here and reread and considered in other modules.

1. Read Chapters 1 - 4, 6 - 8, and 11 in Hale's THE BIOLOGY OF THE LICHENS.

2. List important scientists and technical words on 3" x 5" cards.

3. Consult HOW TO KNOW LICHENS, pages 1 - 12 for good illustrations.

4. Request the PROGRAMMED REVIEW.

5. Data Storage cards requested in Programmed Review.

6. F.I.D. sheets as requested in Programmed Review.

7. Hand in material requested throughout Programmed Review to instructor for credit.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #2;

1. Read Chapter #5 in Hale's THE BIOLOGY OF THE LICHENS.

2. Read Oxford Biology Reader #42 - The Lichen Symbiosis.

3. Request Programmed Review.

4. Data Storage cards are requested in Programmed Review.

5. F.I.D. Sheets are requested in Programmed Review.

6. Hand in material requested throughout Programmed Review to instructor for credit.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

EM-10 THE LICHENS
INSTRUCTION AND CHECK OFF SHEET (cont.)

PACKET #3;

1. Read the Introduction in Hale's HOW TO KNOW THE LICHENS, pg. 1-27.

2. Reread the section (pgs. 119-129) in THE BIOLOGY OF THE LICHENS.

3. Read Chapters 9 and 10 concerned with taxonomy and identification in THE BIOLOGY OF THE LICHENS.

4. REQUEST PROGRAMMED REVIEW.

5. Complete free-hand sectional drawings.

6. Complete orders for F.I.D. notebook.

7. Complete Data Storage cards.

8. Complete technique cards for F.I.D.

9. Submit your samples and kritter sheets on the two lichens you have collected.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: _____________

TAKE END OF MODULE TEST: __________ DATE COMPLETED: ____________________
GRADE: ______________________________

LICHEN CLASSIFICATION

This abbreviated classification scheme is a condensed version of that of Josef Poelt as found in The Lichens, Ahmadjian and Hale. The attempt to develop order from chaos amongst lichens began with Theophrasus in 350 B.C. and has lasted for centuries. It is nowhere near complete. As stated by Poelt:

> *"Even a superficial analysis of any of the past systems will show that we cannot really speak of a true integration of lichenized fungi in any presently accepted fungal system, Lichen systematists have hardly ever been really familiar with the corresponding fungal groups, and mycologists have had enough difficulties with their own groups without bringing in the lichenized fungi. Much remains to be done on important diagnostic characters in all groups."*

There are among the fungi bothersome species which may be called parasitic lichens, parasymbionts and lichen parasites.

Parasitic lichens are those fungi whose fungal activities encourage them to attack other lichens or mosses, but which also contain algae and so are at least partially autotrophic.

Parasymbionts are those fungi which have independent thalli but which on occasion form a weak association with algae without forming a distinctive thallus. (Zopf, 1897)

Lichen parasites are fungi (e.g. Nectriaceae) which actually attack lichens and are never 'lichenized'. These should be classed as fungi.

The taxonomist should be aware that some member of Lecanorales, Arthoniales, Dothideales, Calicales, Verrucariales, Jelotiales, and Pyrenulales may be transitional between lichenized and non-lichenized fungi.

In the key reproduced here no attempt is made to work beyond genus. Species and the more specialized taxonomic ranks subspecies, variety and forma are left to the lichenologist.

Major authors consulted include:

Ainsworth, G. C. 1971. Ainsworth & Bisby's Dictionary of the Fungi, 6th Ed., Commonwealth, Mycological Institute, Kew.

Asahina, Y. and Shibata, S. 1954. Chemistry of Lichen Substances. Jap. Soc. for the Promotion of Science, Tokyo.

Culberson, W. L. 1969. The Use of Chemistry in the Systematics of the Lichens, Taxon 18:152-166.

Culberson, W. L. and Culberson, C. 1970. A Phylogenetic View of Chemical Evolution in the Lichens. Bryologist 73:1-31.

Du Rietz, G. E. 1938. The Fundamental Units of Biological Taxonomy. Sv. Bot. Tidskr. 24:33-248.

Hale, M. E. 1966. Chemistry and Evolution in Lichens. Is. H. Bot. 15:150-157.

Hale, M.E. and Culberson, W. L. 1970. A Fourth Checklist of the Lichens of the Continental U.S. and Canada. Bryologist 73:499-543.

von Krempelhuber, A. 1867-1872. Geschichte und Litteratur der Lichenolgie, Vols. I, II, and III. Munich.

Santesson, R. 1953. The New Systematics of Lichenized Fungi. Proc. 7th Inter. Bot. Congr. Stockholm, 1950. pp. 809-810.

Santesson, R. 1967. On the Taxonomical and Biological Relations Between Lichens and Non-Lichenized Fungi. Bot. Notis. 120:497-49-.

Thomson, J. W. 1963. Modern Species Concepts: Lichens. Bryologist 66:94-100.

Watson, W. 1948. List of British Fungi Parasitic on Lichens. Trans. Brit. Mycol. Soc. 31:305-339.

Zahlbruckner, A. 1922-1940. Catalogus Lichenum Universalis. Vols. 1-10. Leipzig.

NOTE: THESE SHOULD ALL BE IN YOUR DATA STORAGE DECK.

Just as fungi are basically divided into three major groups: ASCOMYCETES, BASIDIOMYCETES AND DEUTEROMYCETES, so too are the lichens derived therefrom:

ASCOLICHENS

Arthoniales
    Arthoniaceae
        Arthonia, Arthothelium, Crypthothecia, Stirtonia

    Opegraphaceae
        Chiodecton, Dictyographa, Enerographa, Enterostigma, Mazosia, Minksia, Opegrapha, Sclerophyton
    Lecanactidaceae
        Lecanactis, Melampydium, Schismatomma, Pseudolecanactis
    Roccellaceae
        Crustose: Dirina, Dirinastrum, Lobodirina, Cyclographa
        Fruticose-foliose: Combea, Darbishirella, Dendrographa, Dolichocarpus, Gorgadesia, Hubbsia, Ingaderia, Roccellaria, Roccellina, Roccellodea, Roccellographa, Sagenidium, Schizopelte, Simonyella

ASCOLICHENS (cont.)

- Chrysotrichaceae
  - Byssocaulon, Chrysothrix, Temnospora

Dothideales

- Pleosporaceae
  - Arthopyrenia, Lejophloeae, Zanthopyrenia, Dermatina, Leptorphaphis, Microthelia, Microtheliopsis, Mycomicrothelia, Mycoporellum, Mycoporopsis, Polyblastiopsis, Sporoschizon, Tomasellia

Verrucariales

- Verrucarioideae
  - Dermatocarpon, Leucocarpia, Placidiopsis, Polyblastia, Sarcopyrenia, Thelidium, Trimmatothele, Verrucaria
- Staurotheloideae
  - Endocarpon, Staurothele

Pyrenulales

- Pyrenulaceae
  - Anthracothecium, Astrothelium, Cryptothelium, Parathelium, Parmentaria, Plagiotrema, Pleurotheliopsis, Pseudopyrenula, Pyrenastrum, Pyrenula
- Trypetheliacea
  - Trypethelium
- Laureraceae
  - Bottaria, Campulothelium, Phyllobathelium, Laurera, Polyblastiopsis
- Strigulaceae
  - Acrocordia, Aspidothelium, Lithothelium, Phylloblastia, Pleurotrema, Raciborskiella, Strigula
- Microglaenaceae
  - Geisleria, Microglaena, Thrombium, Thelenidia
- Clathroporinaceae
  - Belonia, Clathroporina, Porina, Trichothelium

Caliciales

- Mycocaliciaceae
  - Chaenothecopsis, Mycocalicium, Phaeocalcium, Stenocybe, Strongyleuma
- Caliciaceae
  - Allophoron, Calicium, Carlosia, Chaenotheca, Coniocybe, Coniocybopsis, Cyphelium, Cypheliopsis, Farriolla, Pyrgidium, Stephanophoron, Texosporium, Tylophorella, Tylophoron

- Tholurnaceae
  - Tholurna
- Sphaerophoraceae
  - Acroscyphus, Pleurocybe, Pseudosphaerophorus, Sphaerophorus, Calycidium, Thysanophoron

Ostropales

- Ostropaceae
  - Conotrema
- Thelotremataceae
  - Chroodiscus, Diploschistes, Gloeolecta, Leptotrema, Ocellularia, Petractis, Phaeotrema, Polystroma, Ramonia, Thelopsis, Thelotrema, Tremotylium

ASCOLICHENS (cont.)

Graphidales
Graphidaceae
Acanthothecis, Aulaxina, Graphina, Graphis, Glyphis,
Helminthocarpon, Medusulina, Phaeographina, Phaeographis,
Sarcographa, Sarcographina
Melaspileaceae
Melaspilea
Asterothyriaceae
Asterothyrium, Calenia, Echinoplaca, Gyalectidium, Psorotheciopsis,
Tricharia, Absconditella, Gualidea, Petractis, Sagiolechia,
Solorinella
Gyalectaceae
Coenogonium, Dimerella, Gyalecta, Gyalectina, Pachyphiale
Lecanorales
Lichinaceae
Anema, Calotrichopsis, Ephebe, Gloeoheppia, Gonohymenia,
Lemmopsis, Lempholemma, Lichina, Lichinella, Lichinodium,
Phylliscidium, Peccania, Poroscyphus, Psorotichia, Pterygiopsis,
Pyrenopsidium, Pyrenopsis, Rechingera, Synalissa, Thermutis,
Thyrea, Zahlbrucknerella,
Heppiaceae
Heppia, Peltula
Placynthiaceae
Epiphoea, Koerberia, Massalongia, Moelleropsis, Placynthium,
Polychidium, Psoroma, Steinera, Vestergrenopsis
Peltigeraceae
Hydrothryia, Peltigera, Solorina
Nephromiaceae
Nephroma
Lobariaceae
Lobaria, Pseudocyphellaria, Sticta

Families with blue-green symbionts: Classification not settled.
Collemataceae
Collema, Homothecium, Leciophysma, Leightoniella, Leptogium,
Physma, Ramalodium
Coccocarpiaceae
Coccocarpia, Spilonema
Pannariaceae
Erioderma, Pannaria, Parmeliella
Arctomiaceae
Arctomia

Lecideaceae
Aglathecium, Bacidia, Byssolecania, Byssoloma, Catillaria,
Gomphillus, Lasioloma, Lecidea, Lecidella, Lopadium,
Megalospora, Mycoblastus, Phyllopsora, Psorella, Phizocarpon,
Schaerera, Sporopodium, Tapellaria, Toninia

ASCOLICHENS (cont.)

- Lecanoraceae
  - Haematomma, Lecania, Lecanora, Physcidia, Solenopsora, Squamarina,
- Aspiciliaceae
  - Aspicilia, Hymenelia, Ionaspis, Lecanorella
- Hypogymniaceae
  - Cavernularia, Hypogymnia, Menegazzia, Pseudevernia
- Parmeliaceae
  - Asahinea, Cetraria, Nephromopsis, Dactylina, Omphalodium, Pannoparmelia, Parmelia, Parmeliopsis, Platismatia
- Usneaceae
  - Alectoria, Bryopogon, Cornicularia, Evernia, Everniopsis, Himantormia, Letharia, Neuropogon, Oropogon, Sulcaria, Usnea
- Ramalinaceae
  - Desmaziera, Ramalina, Ramalinopsis, Speerschneidera
- Anziaceae
  - Anzia
- Stereocaulaceae
  - Argopsis, Compsocladium, Pilophorus, Stereocaulon
- Cladoniaceae
  - Cladia, Cladonia, Cladoniopsis, Glossodium, Gymnoderma, Heteromyces, Neophyllis, Pycnothelia, Spaerophoropsis, Thysanothecium, Heterodea
- Baemycetacea
  - Baeomyces, Icmadophila
- Siphulaceae
  - Endocena, Siphula, Thamnolia
- Umbilicariaceae
  - Lasallia, Umbilicaria
- Acarosporaceae
  - Acarospora, Ahlesia, Biatorello, Glypholecia, Maronea, Maronella, Sarcogyne, Sporastatia, Thelocarpon
- Pertusariaceae
  - Coccotrema, Melanaria, Ochrolechia, Pertusaria, Varicellaria
- Candelariaceae
  - Candleria, Candelariella, Cadelina, Placomaronea
- Teloschistaceae
  - Brigantiaea, Caloplaca, Fulgensia, Protoblastenia, Teloschistes, Xanthopeltis, Xanthoria
- Physciaceae
  - Anaptychia, Buellia, Buelliastrum, Dimelaena, Diploicia, Dirinaria, Heterodermia, Orphniospora, Physcia, Physciopsis, Physconia, Pyxine, Rinodina, Tornabenia
- Dermatiscaceae
  - Dermatiscum

FAMILIES WITH NO CLEAR RELATIONSHIPS

- Arthroraphidaceae
  - Arthrorphis
- Harpidiaceae
  - Harpidium

ASCOLICHENS (cont.)

Lithographaceae
    Encephalographa, Lithographa
Micareaceae
    Micarea, Rocellinastrum, Scoliciosporum
Pachyascaceae
    Pachyascus
Phlyctidaceae
    Phlyctidia, Phlyctis, Phlyctella
Stenhammarellaceae
    Stenhammarella
Trapeliaceae
    Orceolina, Placopsis, Trapelia
Agyriaceae
    Xylographa

BASIDIOLICHENS

Aphyllophorales
    Dictyonemataceae
        Athelia, Dictyonema, Cora, Corella, Wainiocora
    Clavariaceae
        Multiclavula, Clavulinopsis, Lentaria
Agaricaceous Fungi
    Tricholomataceae - The complex diagnosis of this family is not yet clarified.
        Omphalina

LICHENES IMPERFECTI (DEUTEROMYCETES_

There are a number of lichen species which have never been found with ascocarps. They may be found eventually in some. In a few cases these sterile lichens can be assigned to specific genera (Unbilicaria, Parmelia, Caloplaca) on the basis of certain vegetative characters (thallus structure, chemistry). In other cases a tentative assignment can be made (Pertusaria). Most, however, lack any suitable criteria. They are simply put into artificial genera according to thallus structure (e.g. Lepraria structure) or type of vegetative diaspore (e.g. Phyllophiale). While improved analysis of characters may result in reassignment of some species to definite genera, the greater part of the forms under Lepararia will never be group, although it includes some smaller natural relationships.

The fruticose genera Siphula, Endocena, and Thamnolia have often been cited in the Lichens Imperfecti but they are better placed in a separate family after the Cladoniaceae because of their chemistry.

GENERA: Cystocoleus, Leparia, Leprocaulon, Lichenothrix, Normandina Phyllophiale

EM-10 THE LICHENS

PACKET #1 THE BIOLOGY OF LICHENS by Mason E. Hale
PROGRAMMED REVIEW OF CHAPTERS 1-4, 6-8, and 11

1. The father of lichenology is the Swedish doctor, Erik __________. He introduced the terms soredia, isidia, and __________ to describe the lichen structures. The first reference on lichens was written in 1866 by the German mycologist Anton __________.	
2. Enroll: Annie Smith's Lichens and P. Ozenda's book, Lichens (in Encyclopedia of Plant Anatomy) in your data retrieval system.	1. Acharius cephalodia deBary
3. The fungal component to the lichen vegetative component is called the __________. It is either an Ascomycete or __________ which surround the algal components called the __________. The total vegetative symbiont, the autonomous organism is the __________.	2. If you expect to work in ecological areas you may wish to list other major references to lichens in the data storage system also.
4. As a lichen grows the threads of fungal cells first develop __________, these grow into a __________, which mats into a complex __________. The most primitive lichen genus is __________ whose thaillus is a __________ powdery crust of loosely __________ fungi and algae.	3. mycobiont Basidiomycete phycobiont Thallus
5. The __________ layers of the thallus provide environmental protection. The hyphae are compressed and cemented together with __________. In Physcia ciliata the cortical layer is __________. In Anaptychia hypolinca the layers are __________. In Roccella and Pseudovarnia the cortical hyphae are __________.	4. hyphae mycelium Thallus tepraria scurfy associated
	5. cortical gelatia cellular parallel perpendicular

6. Some lichens have a continuous covering called a __________. Some have withish surface __________. Pigments like anthraquihomes, pulvic acid and usnic acid and crystalline products such as carbonates and oxalates accumulate in the __________.	
7. Most of the lichen Endothallus is __________ tissue. The structure is loose and cottony. Endolithic lichens accumulate __________ cells and all lichens store __________ and colorless organic __________ __________ in the __________. In some lichens attachment to the substrate is by medullary cells called __________. In __________lichens there is not cortical layer nor cuticle; the __________ is replaced by the __________.	6. cuticle pruino thallus
8. The 'captured' algae are confined to a layer between __________ and __________. Sometimes algal cells are loosely held, sometimes specialized hyphae called __________ attach to or even __________ algal cells.	7. medullary oil water lichen acids medulla hyphae squaumulose cortex medulla
9. The __________ is responsible for color, __________, and the gelatinous consistency of the __________, whereas the __________ controls thallus __________.	8. cortex medulla haustoria penetrate
10. Utilize your HOW TO KNOW THE FRESHWATER ALGAE key to produce identification sheets on some of the common algal phycobionts: Trebouria, Coccobotrys, Chlorella, Coccomyza, Nostoc, Stigonema, Cystococcus, Chlorococcum, Trentepohlia, Pleurococcus, Scytonema, Hyphomorpha and Calothrix. Note on your algae sheets that these species are common as algal symbionts.	9. phycobiont shape thallus fungus morphology
	10. Remember that all these sheets are collected to be given credit for this module.

11. Growth forms: Traditionally lichens are classed morphologically as __________, __________, or __________. Actually there are intermediates and exceptions and gradations from this single classification.	
12. If the lichen is pressed against the substrate and cannot be separated from it without scratching it off it is clearly a __________ lichen. If the lichen is leafy, is dorsiventral (has an upper and lower portion), has rhizinal attachment, and is above the substrate surface considerably it is a __________ lichen. If it is hair-like, shrubby, finger-like or strap shaped it is classed as __________.	*11. crustose foliose fructicose*
13. Non-corticated clumps of algae cells surrounded by hyphae are called __________. Draw a soredia and include in F.I.D. notebook. (Note Plate 6). Include in F.I.D. notebook the difference between soredia and soralia. Soralia are common to __________ and __________ lichens.	*12. crustose foliose fructicose*
14. Finger-like projections from the cortex filled with algal cells and hyphae are called __________. (Note Plate 6), for insidia; include in F.I.D. notebook. Insidia act as vegetative __________, that is they break off and reproduce the lichen as they wash or are carried to new sites. Insidia also increase the __________ area of the thallus. If insidia-like growths exist on the bottom of lichen surfaces they are called __________.	*13. soredia foliose fructicose*
15. If sorelia-like structures originate from apothecia they are called __________. Sometimes species are differentiated just because they have or have not __________.	*14. insidia propagiles surface lobules*
	15. hormocysts soredia

16. The compacted strands of hyphae that anchor a thallus to the substrate are called __________. Illustrate these as in Figure 1.12 and Plate 7 in your F.I.D. notebook. They probably act to transport dissolved __________ and organic __________ from substrate to __________. A felty, hirsute, cottony mat of rhizines is called a __________.	
17. The thalline appendages which are hair-like along lobe __________ of many foliose lichens are called __________. In the genus __________ are found large round pit structures on the lower cortex called __________. Cyphallae and pseudocyphellae probably function in __________ exchange and aeration. Cyphallae __________ is useful in identification. If thalloid outgrowths contain foreign algae they are called __________. Captured __________ fix the gaseous element __________ and provide the lichen host or __________ with nitrogen. Illustrate these structures in your F.I.D. notebook.	16. rhizines minerals metabolites thallus tomentum
18. Most lichen fungi belong to the class __________. This group usually has __________ spores within a sac, the __________. The other mycobiont class is __________ which have __________ spores produced on a club-shaped __________. In 1932 the Swedish mycologist __________ divided lichen Ascomycetes into __________ major groups: ascohymenial and ascolocular.	17. margins cilia Stricta cyphellae gas size cephalodia Nostoc nitrogen mycobiont
19. When an ascocarp develops it starts with an __________ coil, then develops a __________ and when it degenerates either a __________ or an __________ develop. Open disc or cup shaped ascocarps are __________. Whiteflask-shaped ascocarps are __________. Sometimes algae and fungi take part in formation of __________. Illustrate examples in the F.I.D. notebook (Fig. 2.5) Also illustrate and identify parts of a pychidia (pg. 37).	18. Ascomycete eight ascus Basidiomycete four basidium Nannfeldt two
	ascogonial 19. trichogyne perithecia apothecia apothecia perithecia ascocarps

20. The __________ lichens differ from ascohymenial lichens in lacking true __________ and having two-walled __________ scattered in __________ of the stroma. Usually if the pseudoparaphyses are __________ and the asci __________ it is an ascolocular lichen. Bitunicate means __________-walled or two-skinned. Paraphyses are thread-like __________ which pack around the asci. NOTE figure 2.6; Place in F.I.D. notebook.	
21. When meiosis occurs the final product in fungi and other plants is a __________. Usually there are __________ spores in an ascocarp. Spores are identified by __________ and form. A septum is a __________. In your F.I.D. notebook show the classification on page 37, and the appropriate drawing, Figure 2.8.	20. ascolocular hymenium asci locules branched bitunicate two hyphae
22. Just as the liverwort Marchantia has __________ and the dicot, Kalanchoe has __________ (there is a live Kalanchoe in the Lab); lichens have vegetative __________. When __________ break off the thallus of a lichen they contain both __________ tissue and __________ cells and can __________ their existence. Crustose lichen genera (rarely, often) develop diaspores. Lichens are not endemic; that is they are not confined to one __________. Often as with Parmelia they extend around the __________. Lichens must rely on __________ reproduction to a large extent to be so universal.	21. spore eight septation wall
23. Sexual __________ production occurs only with the __________; algae do not produce __________. A lichen thallus is reconstituted secondarily through __________.	22. gemmae plantlets diaspores diaspores fungal algal continue rarely location earth vegetative
	23. spore fungus spores lichenization

24. STAGES IN SEXUAL DEVELOPMENT: Show in a ring cycle in your F.I.D. notebook the stages in recreating a lichen thallus. Include: (1) ascogonial coil, (b) trichogyne, (c) microcondial development, (d) ascospore transport, (e) ascospore germination, (f) saprophytic mat formed, (g) thigmotropism occurs, (h) lichenization by several algae forms, (i) unialgal colony: unifungal colony established, (j) prothallus, and (k) thallus.	
25. Evidence for the need of sexual reproduction in lichens comes from three sources: __________cultures, distribution of __________ strains, and putative __________.	24. SUBMIT FOR HELP OR DISCUSSION TO INSTRUCTOR.
26. Recent studies emphasize that a lichen is a __________ creature whose physiology must be studied as a functional unit not divided into component algae and fungi. Lichens resemble an agar gel when considering __________ relations. When compared to other plants they contain (more, less)water. Most lichens absorb water rapidly using __________ of water by a __________gel. Some crustose lichen, however, are covered with __________ organic substances which slow absorption. Lichens lose water slowly and can withstand drought. Related to the poor control lichens have over water control are their slow rates of __________ and __________. Like most plants their response to season is to produce __________ growth curves; that is maximum growth in spring and autumn.	25. monospore chemical hybridization
	26. composite functional less imbibition hydrophilic non-wettable photosynthesis respiration bimodal

27. Lichens are unique chemically. They accumulate __________ and __________ nutrients. The process requires the use of ___________ energy. How do lichens obtain nitrogen? How do lichens obtain carbon? Do lichens accumulate metallic ions?	
28. List the mechanisms by which lichens absorb large concentrations of metal.	27. organic mineral metabolic -N -via decay of other organic materials & via Nostoc as symbiont -C -from simple organic decay production & from glucose via algal photosynthesis -metals -lichens strongly concentrate metallic ions.
29. Can algal and fungal components be separated? Can they grow separately? What can be determined by such studies?	28. cystoplasmic resistance immobilization of metal ions via chelation active and passive transport to local centers.
	29. -yes... -yes... but slowly -nutrition studies, vitamin requirements, pH, temperatured light, and product synthesis. Much work remains to be done in this area.

30. Lichens display a __________ pattern of growth. Older parts change function but do not __________. Growth rates are always __________, but do vary from place to place for the same species. Glacial moraines can be dated using __________. Seasonal growth variation can be studied by measuring __________ area changes. All lichens live at least ten years, some are estimated to live _____ to _____ years. Lichens are very sensitive to air __________. (Note Ferry, Baddeley and Hawksworth, POLLUTION AND LICHENS). Major causes of lichen death are: __________-dioxide, __________, deforestation, oil pollution, snails, and __________ radiation.	
31. Lichens are called the __________ in plant succession. NOTE; Barkman on ECOLOGY OF CRYPTOGANIC EPIPHYTES. Lichens when shaded or covered with leaf litter soon die to be supplanted by __________ lichens, __________ and then higher plants.	30. centrifugal (orbiculax) die slow lichenometry surface 30-50 (artic lichens 4500 years) pollution sulfur fluorine ionizing
32. Lichenologists have classified lichen communities as orders (federations) which are designated by adding to suffix-__________ to a __________ or __________ name. Federations are made up of __________ demoted by the suffix-__________. NOTE: DuRietz, Braun-Blanquet, Klement, Laundon.) The lichen terms Cladonia, Graphis, Lobaria are all __________. The terms comizaeoides, Lepraria, olivacea, are all __________. Xenthorion is an ecological __________ dominated by the orange-colored genus __________. DO YOU UNDERSTAND HOW TO NAME LICHEN COMMUNITIES?	31. pioneers mezophytic bryophytes
	32. -ion genus species unions -etum genera species federation Xanthoria

33. What factors determine corticolous distribution? Name three.	
34. Saxicolus communities: Saxicolus communities of lichens are those which inhabit __________. In urban areas the substrates may be __________. Most lichens are very __________ as to rock substrate. Collenataceae, Physciaceae, and Telcschistaceae dominate __________ rocks, while __________ and __________ prefer acidic rocks. Some lichens grow on __________. In New England a 'climax' lichen flora is NOT reached in an orderly manner. EXPLAIN!	33. substrate specificity bark pH water-holding capacity
35. Lichens often live in or next to water. These are the __________ habitants. Lake habitats are called __________; marine habitats are high-tide, __________, and __________ zones. When trees are rare or absent __________ communities of lichens may develop. The most common soil federation is the __________.	34. rocks concrete specific basic Parmeliaceae Umbilicariaceae dung (guano) Lichens grow, expand, die, are replaced, rock spills, new species invade, recycling
36. List several important intracellular carbohydrates found abundantly in lichens. What other organic compounds characteristically are found in lichens?	35. aquatic lacustrine intertidal spray soil Cladonion
	36. lichenin isolichenin pustulan glucans chitin sucrose alpha-trehalose umbilicin erythritol D-mannitol volemitol siphulitol carotenoids free amino acids vitamins

37. Hesse and Kopf began the intensive study of lichen __________ substances. Modern classification depends upon an understanding of __________ pathways. Complete Shibata's Classification Scheme from page 106. You are not responsible for detail beyond this table. Do note however the rest of page 106 through 117 to see how much is known. Note for information retrieval, Asahina, Culberson, Neela-Kantan, and Huneck.	
38. The role of Lichen Substances (page 118). List the possible uses for these strange organic compounds.	37. extracellular synthetic
39. Lichen substances are identified by __________ reactions, __________, analysis, __________ absorption spectra, mass __________, partition __________ and by specific __________ tests. Color tests were discovered and systematized by __________ in 1866. Microchemical tests were perfected by the Japanese chemist __________ in 1936.	38. reserve food increased capacity light absorbers water uptake control palatability-bitter antibiotic
40. Lichens taste __________, but some lichens, especially rock __________, are edible. They are important food sources to __________, __________, __________, __________ and Libyan sheep. A number of invertebrates secrete __________, an enzyme which breaks down __________ into glucose. Lice-like insects of larch trees are called __________. Minute, slow moving arthropods are called __________. Snails, slugs, psocids, and tardigrades all like to eat __________.	39. color fluorescence ultraviolet spectrometry chromatography microchemical Nylander Asahina
	40. bitter tripe deer lemmings reindeer caribou lichenase lichenin psocids tardigrades lichens

41. Lichen substances are often __________ against G+ bacteria (but not against G- bacteria). Tomato canker (__________ __________) is killed by sodium __________ (F.I.D. notebook).	
42. The blue-staining wood fungus __________ is inhibited by vulpinic, physodic, salaninic, and usnic acids. Usnic, lecanoric, and psoramic acid are effective against __________ __________ __________. Some lichen substances are antifungal. What harmful effects of lichens are known?	41. antibiotic Corynebacterium michiganensis usnate
43. Dyes are made from the fructicose lichen __________. Crottal (__________), Parmalia, and Evernia are used today in __________. Harris tweeds are mostly because of __________ dye. The acid-base indicator __________ is derived from __________-containing lichens. The chromosphore which causes the blue-red color change is 7-__________. Can lichens hurt trees? Draw the lecanoric acid moiety and show the chelation point in red pen.	42. Trichosporium tobacco mosaic virus (TMV) allergic reactions to dust arctic peoples accumulate radioactive cesium and strontium
	43. Rocella Ochrolechia Scandanavia lichen litmus depsid oxyphenoxazon lichens might hurt bark and slow growth submit drawing to lab assistant

EM-10 THE LICHENS
PACKET #2 - THE LICHEN SYMBIOSIS

1. Lichens are a large group of plants containing about ________ of all known species of fungi. differences in color of Mars could be caused by alternate ____________ ___________ _________ of lichen patches. Most of the tundra is carpeted by two _____________ lichens: C_____________ _______________ and Ce______________ ______________. It was _______________ who in 1867 first recognized that lichens were really two symbiotic plants. There are about ______________ lichen species known today.	
2. Most genera of algae associated with lichens are _________________ not aquatic. The most common phycobiont is a _____________ sp. which has not been found free-living. Another common symbiont is the filamentous green algae _________________. Nostoc is a ___________-________________ algae classed by modern bacteriologists as a ____________________.	1. ¼ drying and wetting fructicose Cladonia rangiferina Cetraria islandica PUT THESE TWO LICHENS IN F.I.D. NOTEBOOK Schwendener 18,000
3. One problem posed by the occurence of lichen syntheses in nature concerns ________________, the most common algal symbiont. Since soredia, which contains both algal __________ and __________ hyphae are not formed by most lichens how do those which only produce fungal spores reconstitute the symbiotic relationship? Explain.	2. terrestrial Trebouxia Trentepohlia blue-green photobacteria
4. (a) Have experiments proved that the fungus gains something from its symbiotic life with the algae? (b) What text would you consult to find out how to separate algal from fungal cells?	3. Trebouxia cells fungal Soredia of one species land on prothallus of lichen which does not have a phycobiont and lichenization occurs.
	4a. Yes. In the last eight years proof that products of algal synthesis move into fungal cells has been found. 4b. Ahmadjian's The Lichen Symbiosis DATA STORAGE CARD!!!

EM-10 THE LICHENS
PACKET #2 - THE LICHEN SYMBIOSIS (cont.)

---

5. Symbiosis exerts a ________________ influence on morphology. Fungal cells are notably ________________ in the vitamins ____________________ and ________________. Is vitamin deficiency unusual in fungi?

---

6. What are the results of trying to grow lichens by artificial synthesis in the laboratory? (a - f)

5. profound (great, terrific, controlling)
deficient
biotin
thiamin
vitamin deficiency is unusual when a fungus is in its normal soil environment.

---

7. From the foliose lichen study using ^{14}C what is the suspected sequence of events from algal cell to fungal hyphae?

6. a. if inoculated together on agar they do not associate.
b. if nutrients become scarce lichenizathesis begins
c. wetting and drying -stress-promotes association.
d. synthesis is encouraged by presence of proper substrate.
e. the fungus is not particular at first as to what algae it surrounds, Later it is specific.
f. fungal tissue differention only occurs when association is complete.

---

8. The inhibition ________________ has been used to show that Nostoc Calothrix and Smytonema transfer via (a) ________________; Trevouxia, Myxmecia and Coccomyxa via (b) ________________; Trentepohlia via (c) ________________; and Myalococcus and Stichococcus via (d) ____________________.

7. algal cell makes glucose. Glucose moves from algal to fungal cells. Fungal cell converts it to nannitol and stores it.

---

8. technique
a. glucose
b. ribitol
c. erythritol
d. sorbitol

EM-10 THE LICHENS
PACKET #2 - THE LICHEN SYMBIOSIS (cont.)

---

9. It is a remarkable feature of all known __________ symbionts that their ______________ partners always convert the products they receive to other ___________ before accumulating them as stored food. Nostoc possesses the enzyme _____________ which catalyses the reduction of ____________ gas to _________________.

---

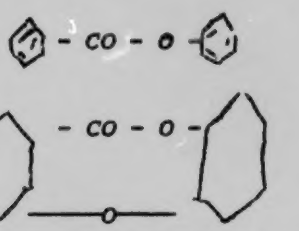
10. Draw the structural formulae for the depsides and depsidnes.

9. autotrophic
heterotrophic
compounds
nitrogenese
nitrogen
ammonia

---

11. Peveling has shown that the __________ of the fungal hyphae is ______________ in the region of contact with the algal cell. When a fungal _____________ penetrates an algal cell the algae ___________________.

10.



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12. List changes which occur when an algal cell is removed from capture of the fungal hyphae.
NOTE: BE SURE TO INCLUDE YOUR VERSION OF THE CONCLUSIONS FOUND ON PAGE 16.....INCLUDE IN DATA STORAGE THE GENERAL AND REFERENCE READINGS FROM THIS ARTICLE.

11. plasmalemma
convoluted
haustoria
dies

---

13. What did DeBary (1866) and Schwendener (1867) discover? Can you differentiate between parasitism, endosaprophytism, mutualism, polysymbiosis, parasymbiosis? What have Famintzin and Culberson complained about?
DO YOU HAVE TERM CARDS MADE UP FOR TERMINOLOG Y IN THIS MODULE?

12. -carbohydrate permeability of cell wall to transfer sugar decreases.
-insoluble cell materials accummulate in algal cell
-muscilaginous coat rebuilt
-motility returns

---

13. Conidia are free-living algae and lichens are unions of two entirely differenct plants.
Famintzin & Culberson feel that lichens have been growing together so long that they are separate plants from fungi and algae

14. Place Figure 5-1 (Hale's Biology of Lichens) in your F.I.D. NOTEBOOK, Who has accomplished lichen synthesis?

14. Ahmadjian says that Stahl, Bonnier, and Stahl have produced viable lichens from component algae and fungal strains. HE DID ALSO!!!!!

EM-10 THE LICHENS
PACKET #3

HOW TO KNOW THE LICHENS - BE SURE YOU HAVE READ THE INTRODUCTION TO THE LICHENS BY HALE AND THE SECTIONS IN THE BIOLOGY OF LICHENS (pgs. 119-129), AND CHAPTERS 9 AND 10 CONCERNED WITH TAXONOMY AND IDENTIFICATIONS BEFORE DOING THIS REVIEW.

---

1. What kind of lichens are most difficult to identify? What reference must be consulted to study them? What are the difficulties involved with illustrating algae?

---

2. Algae, fungi, mosses, liverworts a nd anthocerots are all commonly called _______________. Lichens are also ____________. Lichens generally are ____________ in outline and between 1 cm and ____ cm in diameter. Usually lichens require a _____________ binocular microscope (10-30x) and a good ________________ microscope before identification to ______________ can be accomplished. Color is judged only after the thallus is _________________. How do you judge color in this key? ______________ __________________ _____________ _______________________.

1. -crustose forms very difficult and more rare in U.S.
   -consult Fink's LICHEN FLORA OF N.A. (Note on data storage card)
   -algae difficult to draw, expensive to photograph

---

3. What are the four growth forms used in Hale's Key? _______________, _________________, ___________________, and _________________. To what group _________________ do rock tripes belong? _______________. How do they differ from other foliose lichens? _______________________. What is this attachment? ____________________. If the lichen cannot be peeled from the rock or bark it is called ______________ __________________ or ______________________. Lichens can also be 'loosely' adnate; it is difficult to judge degree of 'adnateness".

2. cryptogams
   cryptogams
   round
   30
   stereoscopic
   compound
   species
   air-dried
   color key in frontispiece

---

4. Lobos must be ____________ carefully. Narrow are __________ to ____ mm wide; broad are ____________ to _____ mm wide. Draw and examine lobe _______________ carefully. Note _________________. What should the technician note about upper and lower surfaces? ____.

3. foliose
   fructicose
   crustose
   squamulose
   foliose
   attached at one point not over whole lower surface
   umbilicus
   closely adnate
   appressed

---

5. measured
   0.1-2.0 mm
   3-20 mm
   margins
   cilia
   wrinkling ridges
   pseudocyphellae

EM-10 THE LICHENS
PACKET #3 (cont.)

5. Free hand sections of the thallus are examined. Draw the three sections: ________________, ______________ and ________________.	
6. In 1890 the Finn, ______________, suggested that although lichens are not just fungi they should be classed as _____________. As late as 1911 83% of botanists polled considered lichens as a __________________ plant group. Unfortunately lichenologists have chosen as a basic taxonomic reference a catalog by A_____________, Catalogus Lichenum U_______________ Zahlbruckner based his system on that of ____________ who thought lichens were a __________ class of plants.	5. cortex algal layer medulla
7. Many lichenologists use the "Reinke-Zahlbruckner-Fink" system but we shall employ the modified Nannfeldt-Luttrell system on page 149 for Class Ascomycetes and page 154 for Class Basidiomycetes. Prepare a page for your F.I.D. notebook showing these classes and orders. Arrange your notebook to order and level. Use the keys and arrange the sheets within the orders.	6. Vainco fungi separate Zahlbruckner Universalis Reinke special
8. Some lichenologists use highly specialized laboratory techniques as aide to identification. Name these methods (five). Of these techniques only microelement testing and partition chromatography are possible at NHVTC.	7. Remember 'kritter sheets' will be collected at the end of this module.
9. Of the hundreds of different lichens chemically tested in the past century, the majority have ________________ chemical composition regardless of ____________ or ______________ origin.	8. a. fluorescence analysis. b. ultraviolet absorption spectra. c. microchemical testing d. partition chromatography e. mass spectrometry
	9. constant substrate geographical

10. The basic patterns of strain formation can be interpreted as metabolic shunts where the ___________ - ________________ are stable _____________ lichen substances deposited on the ______________ of the hyphae. (Metabolic shunt is a DEAD-END, short-cut to an organic product.)	
11. Place the references in Hale with those from packets 1 & 2 in the DATA STORAGE SYSTEM.	10. end-products crystalline surface
12. Be sure that the techniques needed to identify lichens are in your F.I.D. NOTEBOOK.	
13. Now look on trees, on ledges, on stone walls and find two lichens to identify.	

EM-10 LICHENS
END OF MODULE TEST

I. TECHNICAL TERMS - MATCHING

1. _____ *Trebouxia*
2. _____ inhibition technique
3. _____ *Nostoc*
4. _____ lichen substances
5. _____ mobile carbohydrates
6. _____ soredia
7. _____ epiphyte
8. _____ *Cladonia*-*Lecidea* & *Dermatocarpon*
9. _____ cephalodia
10. _____ penthecium

A. possesses enzyme nitrogenase
B. spore bearing organ
C. growing on surface of another creature
D. depsides and depsidones
E. flask-shaped
F. commonest symbiont of lichens
G. squamulose
H. tiny warty thalli
I. follow pattern of carbohydrate movement in symbionts
J. ribitol-erythintol

II. DESCRIBE HOW TO IDENTIFY A LICHEN DISCUSSING MORPHOLOGY, FORM, COLOR AND CHEMISTRY.

III. DESCRIBE HOW THE TECHNICIAN WORKING ON AN ENVIRONMENTAL IMPACT ASSESSMENT MIGHT UTILIZE PAST AND PRESENT LICHEN DIVERSITY INDICES.

IV. DESCRIBE HOW TO CULTURE LICHEN SYMBIONTS SEPARATELY.

V. LIST TEN MAJOR REFERENCES USEFUL IN LICHEN ANALYSES AND IDENTIFICATION.

EM-10 PROTOZOANS
END OF MODULE TEST (cont.)

USING YOUR KRITTER SHEETS CHOOSE TEN(10) SPECIES REPRESENTING WIDELY SEPARATED FAMILIES. DRAW THE PROTOZOAN AND SHOW ITS IMPORTANT DIAGNOSTIC FEATURES AS WELL AS THE USUAL ORGANELLES.

EM-11 THE ACTINOMYCETES

PURPOSE:

To introduce the ray fungi, now known to be bacteria and classed as ACTINOMYCETALES.

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EM-11 THE ACTINOMYCETES (cont.)

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OBJECTIVES: To enable the student to:

1. Understand actinomycete taxonomy.
2. Capture actinomycetes.
3. Culture and maintain these bacteria.
4. Produce slides, slants and plates of these microorganisms.
5. Compare classical morphological taxonomy techniques to modern Adsonion numerical, biochemical and genetic methods.

DATE STARTED: ____________________

EM-11 THE ACTINOMYCETES INSTRUCTION AND CHECK OFF SHEET

In this module you will capture, view and identify members of one of nature's most interesting groups. Now we know they are bacteria, but not long ago they were thought to be fungi. Although some of them cause disease, most are useful soil saprophytes. They produce many useful antibiotics and in the future may provide us with FOOD. You will use two important references in this module: Wakman's, The Actinomycetes and Sykes and Skinner's, Actinomycetales.

PACKET #1:
Read Waksman - pgs. 1 - 42. Utilize the Programmed Review.

DATE COMPLETED: ____________________
SCIENTISTS CARDS: ____________________
KRITTER SHEETS: ____________________
DATA STORAGE CARD: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2:
Read Waksman, ppgs. 42-57 and ppgs. 1-9 in Actinomycetales by Sykes and Skinner. Complete the Programmed Review.

DATE COMPLETED: ____________________
CAUSES OF VARIATIONS: ____________________
DATA STORAGE CARD: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3:
Capture a Soil Actinomycete.

DATE COMPLETED: ____________________
ISOLATE SLANT: ____________________
THREE SLIDES: ____________________
KRITTER SHEETS: ____________________
CLASSIFICATION: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4;
Chemical Composition and Actinomycete Classification. Read the accompanying xeroxed article, place in Data Storage Deck. Utilize the Programmed Review.

DATE COMPLETED: ____________________
SUSPECT #1: ____________________
SUSPECT #2: ____________________
DATA STORAGE CARD: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #5:
Nomenclature and Taxonomy of Actinomycetes. Read pages 61-74 in Waksman The Actinomycete and compare to the more extensive treatment in Sykes and Skinner's Actinomycetales, pgs. 1-91. Utilize the Programmed Review.

DATE COMPLETED: ____________________
TAXONOMY ESSAY: +____________________
BEST '20' KRITTER SHEETS: ____________________

END OF MODULE TEST: ________________ DATE COMPLETED: ______________________

EM-11 THE ACTINOMYCETES
PACKET #1

1. Actinomycetes ________ bacteria.	
2. Actinomycetes ________ unicellular.	1. are
3. Actinomycetes ______ form mycelia	2. are
4. Fungi form mycelia too, but ________ unicellular.	3. do
5. Actinomycetes are closely related to bacteria, as shown by their ____________; chemical ______________ and ___________ activities.	4. are not
6. One genus, especially resembles and may be related to mycobacteria or cornebacteris.....that is the genus ____________. The most fungi-like genera are __________ and ____________.	5. size composition biochemical
7. Fungi have nuclei and mycelia; actinomycetes ______________ nuclei and __________ mycelia.	6. Nocardia Streptomyces Micromonospora
8. Fungi are not attacked by phages; actinomycetes __________ attacked by phages. Fungi are not sensitive to bacterial antibiotics; actinomycetes ___________ affected by bacterial antibiotics.	7. have not have (they have chromatin granules distributed through their cells.)
9. Chitin and cellulose are __________ from cell structures of fungi. Are these biochemicals present in actinomycetes?	8. are are
10. The first photograph of an actinomycete was in 1875 by Ferdinand __________ who called it Streptothrix, but it is now known as a _________________.	9. present in fungi absent in actinomycetes
	10. Cohn Streptomyces sp.

11. In 1877 ____________ discovered the lumpy ______________ pathogen and called it ____________ ________________.	
12. In 1890 ___________ and Lachner-Sandoval grouped the unicellular mycelia bacteria as ____________. Sanfelice noted that the actinomycetes are related to ____________ organisms. In 1892 ______________ recognized that actinomycetes produced aerial spores and pigments in response to ______________ technique.	11. Harz jaw Actinomyces bovis
13. Record in your card system the contributions of the other scientists who contributed to actinomycete understanding. (THIS SHOULD HAVE BEEN DONE AS READING) You are responsible for: Beijevinck, Krainsky, Waksman, Curtis, Lieske, Orskov, Jensen, Krassilnikov, Henrici, Gratia, Dath, Rosantaha, Globig, Hiltner, Störmer, Fousek, Miquel, Tsiklinsky, Rossi-Doria, DeVries, Rossi-Cholodny, Le Chevalier, Perlman.	12. Gasperini actinomycetes tuberculosis Gasperini cultural
14. Name three antibiotics derived from actinomycetes.	13. NOTE THAT MANY OF THE SCIENTISTS ARE PRIMARILY BACTERIOLOGISTS AND MYCOLOGISTS.
15. The terms "actinomycete" and the plural "Actinomycetes" are 'catchall' terms and mean all the organisms now included among ________________, Order; exclusive of __________ and ____________.	14. actinomycin streptothricin streptomycin (NOTE NOW PG. 208)
16. Actinomycetes prefer soil and composts over _____________ sea environments; alkaline and neutral conditions over ___________ conditions. Streptomyces sp. like ______________, Micromonospora sp. like ____________; Actinomyces and Nocardia sp. attack __________. High temperature environments are inhabited by _________________.	15. Actinomycetales Actinomyces Streptomyces
	16. deep acid compost (soils) muds animals (man Thermoactinomyces

17. How do actinomycetes vary with depth as compared to accompanying eubacteria?	
18. At pH below __________ most actinomycetes cannot exist for long. In a peaty soil what number of actinomycetes might be expected per gram dry soil? ________________. In a dry sandy poor soil how many actinomycetes/gram? ________ What conditions favor sporulation of actinomycetes? _____________ What actinomycetes are associated with oil pollution? _________________.	17. actinomycetes and bacteria both decrease in numbers with depth in soil BUT....actinomycetes increase in % microbial count; they dominate at depth.
19. What peculiar symbiosis is shown by Norcardia rhodnii?	18. 4.8 (is critical pH) 1-2 million!!!!!! 10,000 high temperature dry conditions nocardiae and micromonopores
20. What four characteristics of an actinomycete colony differentiate it from bacteria or fungi colonies? ____________, __________, _____________ and _____________. What do they usually have aerially? _______________________________________	19. Taken up by reduvid bug Rhodnius prolixus and necessary if bug is to reproduce.
21. How do actinomycetes grow in liquid media? ______________________________ Can they be filtered? ____________________________ ____.	20. leathery conical compact dry surface USUALLY ACTINOMYCETES DEVELOP AERIAL MYCELIA AND SPORES
	21. flakes or small masses liquid is left clear. They can be filtered and spores and mycelia caught.

22. (a) What may be added to actinomycete media to slow fungi? ________. (b) Bacteria? ________. (c) What stains are useful with actinomycetes? ________ ________. (d) What types of surfaces characterize actinomycete spores (4 types)? ________ ________. (e) What does phalangiform mean? ________ ________ ________.	
23. Actinomycetes have two kinds of spores: ________ and ________ (or chlamydospores). Morphology of actinomycetes depends upon (a) the ________ of the organism itself; (b) the ________ of the medium; (c) the ________ of growth (especially aeration); and (d) the ________ of growth-stimulating (or inhibiting) agents. (e) What did Hopwood prove? ________ ________.	22. (a) nystatin cycloheximide (b) polymyxin penicillin (c) acid stains like erythrosin and rose bengal, phenol-erythrosin (d) smooth, warty, spiny, hairy (e) spores in chains like knuckles on fingers
24. Place in your Field Identification Notebook a description of the two forms of actinomycete colonies from pp. 29-30. Reproduce pg. 11, Figure 2-2 for the notebook.	23. true conida, arthrospores (a) nature (b) composition (c) conditions (d) presence (e) aerieal hyphae develop directly (asexually) from substrate mycelium see page 30: Fig. 3-2
	24. Submit these sheets for comments by instructor

---

25. Bacteria often produce capsules; actinomycetes produce ____________________. 'Ray fungi' are actinomycete mycelium _________________________. Aerieal mycelium often show metabolite induced _______________________. Coloration in both aerial and submerged mycelia is produced by cellular ______________________. Equidistantly spaced sporulating hyphae are called ____________. Shinobu described these kinds of verticles (3) _______________, __________________ and ___________________. Clumped aerial hyphae are called ___________________. Sporulation may occur by three major processes _____________, ________________ and ______________________.

---

26. To 'keep' actinomycetes __________________ media should be used rather than synthetic media. Yeast-glucose, tomato-paste-oatmeal, or a soil (humus rich) agar are useful. Cold, rapid drying (freeze-drying) of actinomycetes is called ______________________. These lyophilized cultures keep for long periods under refrigeration. Plates of healthy actinomycetes may be kept by covering them with ________________ solution but they will die.

25. clubs
granules or 'stars'
zonation or concentric ring structure
pigments
verticella
Nitella, Anitells
tufted
coremia
fragmentation
segmentation
Micromonosporaform (which is distinct to this genus)

---

26. organic
lyophilization
formaldehyde

EM-11 THE ACTINOMYCETES
PACKET #2 PROGRAMMED REVIEW: THE ACTINOMYCETES: A SUMMARY OF CURRENT KNOWLEDGE, WAKSMAN

---

1. The major factors that influence variability of actinomycetes comprise (A) ______________________________; (B) ______________________________; (C) ______________________________ and (D) ______________________________.	
2. Using Table 4-1 how many strains of *Streptomyces coelicolor* might Stanier suggest from the evidence.	1.A. the previous history of the culture. B. nutritional conditions C. genetic constitution D. environmetnal changes
3. What is polymorphis? ______________________________	2. Did you find nine
4. Place in F.I.D. Notebook the CAUSES OF VARIATION, pgs. 44-46.	3. Discuss with instructor if you need more help here.
5. Mutations are variations in characters which are ______________. Strangest of all mutations are ______________ which appear as sectors in colonies with quite different characteristics. They arise from ______________ and develop as ______________. The product of saltation is a ______________.	4. Show this work to instructor as part of this unit.
6. The mutagenic agents are those which cause ______________. Name some of these 'agents'. What is a phage? ______________________________.	5. inherited saltations mutations clones saltant
	6. mutation AGENTS: neutrons x-rays UV-light ethylenimine phages A PHAGE is a virus which attacks bacteria or other microbes.

7. In what ways may actinomycetes ADAPT to changing conditions? ______________________________
____
____.

8. What makes possible the rapid adaptability discussed on pages 51 and 52? __________________
____
____
____
____.

7. adapt themselves to changes in: O_2 tension, temperature, salt concentration, antibiotics.

9. What is an actinomycete mutagenic action?
____
____
____
____.

8. They reproduce rapidly and have a terrific chance for genetic recombination: "The genotypes set the potential limits of adaptability, the environment determines the actual phenotype."

10. Be sure to read the last section "Effect of Genetic Changes upon Speciation", pg. 57. This is why actinomycetes are difficult to 'pigeonhole'. This is why the taxonomy of Actinomycetes is still in a state of rapid change.

9. metabolic products of actinomycetes cause genetic change in bacteria or other microbes.

10. If any questions discuss with instructor. Hand in all materials for F.I.D. book and Data Storage cards.

EM-11 THE ACTINOMYCETES
PACKET #3 CAPTURING A SOIL ACTINOMYCETE

Soil actinomycetes, the ray fungi, are bacteria which show some morphological characteristics of fungi. Their vegetative mycelium does not fragment into bacillary or coccoid forms; their colonies on agar are cohesive, tough, and crumbly. When a total soil microbe count is made actinomycetes are usually found. Often they account for ten to twenty percent of the colonies which are viable. In some soils fifty percent of the colonies are actinomycetes.

Most of the soil actinomycetes are streptomycetes.....that is most belong to the Order Actinomycetales but are in the single genus Streptomyces.

AN ACTINOMYCETE COUNT

MEDIA:

WATER BLANKS: Using the 100 ml bottles provided prepare one bottle with about three dozen glass beads and 95 ml of distilled, deionized (d.d.) water and seven other bottles with 90 ml of d.d. water and no beads. These may be prepared well ahead of a test run and stored. Steam sterilize.

SOIL EXTRACT: For bacteria, actinomycetes, and fungi a soil extract diluent is prepared to provide a normal trace element background for future agar solutions. To prepare:

1. *Mix 1 kg of local fertile soil with 1.5 liters of tap water.*

2. *Autoclave at 15 psi for 15 minutes.*

3. *After partial cooling and settling, filter the supernatant suspension using a Buchner funnel, filter aid.*

4. *If not yet clear let it stand in refrigerator at 40°C overnight and decant into sterile container.*

5. *Store close to freezing point until used.*

ACTINOMYCETE AGAR: Prepare only when dilution series is to done.... that is when ready to make a run.

SAMPLING: Obtain a thoroughly mixed, gross field sample; transfer about one pint in poly bag to lab. Store at 4°C for no more than two weeks before testing. When ready to use pass sample through sterilized 10-mesh screen, mix and remove sample (a portion of) for water content determination.

if you are to make a run.....start autoclaving actinomycete agar now.

DILUTION SERIES: Transfer 10 grams of moist soil to a sterile glass-beaded water blank using waxed paper and brush. Cap. Shake vigorously for fifteen minutes.....Remove 10 ml liquid using a sterile pipette; transfer

EM-11 THE ACTINOMYCETES
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DILUTION SERIES: Transfer 10 grams of moist soil to a sterile glass-beaded water blank using waxed paper and brush. Cap. Shake vigorously for fifteen minutes.....Remove 10 ml liquid using a sterile pipette; transfer to unbeaded water blank. This establishes a 10^{-2} dilution. Similarly transfer from this bottle using another sterile pipette to produce 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7} dilutions. Start with the highest dilution (10^{-7}) and using the same 1 ml pipette transfer to three sterile petri plates samples from that dilution. Move up the series with three plates for each dilution until 10^{-4} dilution to obtain twelve plates. If agar is cool to touch on wrist then pour 8 to 10 ml into each plate by lifting covers and pouring. When all twelve plates are poured shut covers, allow to set, and then incubate in dark drawer (desk) for 7 - 10 days in humid box. (Omit colonies on those plates showing $<$ 300 but $>$30. Indicate count om the chart on the following page.

DILUTION	10^{-4}	10^{-5}	10^{-6}	10^{-7}
PLATES 1				
PLATES 2				
PLATES 3				

If plates are contaminated by bacteria or fungi do not count but so indicate in records.

Using information from moisture determination find actinomycetes/gram dry weight of the soil.

ISOLATION: Streak one of your isolates onto an Actinomycete agar plate to purify. Repeat if in doubt. Maintain your isolate on a slant. Produce three stained slides placing spots on the slide so as to leave space for a label. Stain with crystal violet, eosin, methyl violet, methylene blue, and/or G-stain. Draw the colony and cellular morphology on a kritter sheet. Use packet #5 to classify as far as possible.

EM-11 THE ACTINOMYCETES
PACKET #4 - COMPLETE THE FOLLOWING PROGRAMMED REVIEW AFTER READING THE ASSIGNED MATERIALS.

---

1. The authors contend that most classifications are actually ________________. Color and ________________ are controlled by the ________________ composition of polymers in the organism.	
2. The authors suggest that the ________________ or absence of specific chemical compounds make possible the differentiation between actinomycetes.	1. chemical morphology chemical
3. Some of these specific ____________ ____________ may be fundamental ________________, that is molecules structurally - permanently - a part of the bacteria. Other ________________ chemical compounds may be metabolites, that is products of life processes..... active chemicals which exist in bio-chemical ______________________________.	2. presence
4. By using chemical techniques actinomycetes ________________ be classified to generic level. If morphology is used, as well as chemical anlysis, they ____________ be assigned to a genus.	3. chemical compounds molecules specific pathways (reactions)
5. Separation between taxa ___________ be based upon a single criteria. A taxa (plural, taxon) is nothing more than a unit of ___________________.	4. may not may
6. Pharmaceutical properties in plants are often due to ______________. Attempts were made in the 19th century to classify ______________ ___________ by ________________ content.	5. should not classification
7. Most naturally occurring alkaloids are found in ____________. A few are found in _____________. They are _____________ with a __________ taste and show a strong physiological ___________. They possess ____________ rings containing the element ______________. They are __________ rotary. They exist as salts of acetic, oxalic, lactic, tartaric and fumaric ________________.	6. alkaloids vascular plants alkaloid
	7. plants animals basic bitter activity heterocyclic nitrogen levo (rotary) acids

8. The same alkaloid may exist as a ______________ in different plants and yet be devised in a different biochemical ________________. E.G.: anabasine in the Solanaceae (Nightshade) Family and in Leguminoseae.	
9. Needle- shaped bundles of crystals of calcium oxalate called ________________ were used by Robert _________________ as a chemical ________________ criterion.	8. metabolite pathways
10. Algae are classified according to the __________ they contain which give them color; the ____________ of their __________________ ___________, and the nature of their food __________________.	9. rhaphides Brown taxonomic
11. Some protozoans and some mycetozoa deposit shells, tests or loricas of ____________, ______________, _______________ or lime.	10. pigments composition cell wall storage
12. In fungi, chemical tests are very useful. The presence of starch or glycogen is found by the _______________ test. Chemical analysis of the fungal cell ____________ may detect _____________, ______________ with glucan, and _________________ in yeasts.	11. cellulose chitin silica
13. Lichenologists base a large share of their classification upon ____________ tests. Nylander introduced the calcium ____________ (C), potassium ______________ (K), their combination (KC), and ____________ (P) to test lichen tissue.	12. amyloid wall cellulose chitin mannan
14. The viruses are classified almost completely by _________________ techniques. Important are the _______________ acid count, _______________ and the virion's content of ______________ and __________________.	13. chemical hypochlorite hydroxide p-phenylenedianime
	14. chemical nucleic capsid' structure protein lipid

15. Bacteriologists utilize __________ presence or absence for taxonomic purposes. The streptococci and salmonellae are broken down to species and type with ______________ methods. Production or lack of ______________ enzymes is useful. Group specific ___________ cause ______________ reactions.	
16. The actinomycetes are members of the Phylum ______________ which include bacteria. When we say actinomycetes we mean those bacteria in the order ________________________.	15. enzyme serological hemolytic antigens agglutination
17. The streptomycetes are ________________; that is, members of the order _____________________.	16. Schizomycetes Actinomycetales
18. Streptomycetes produce ____________ pigments, that is, pigments which leave the organism and ______________ into the medium in which the bacteria grows.	17. Actinomycetes Actinomycetales
19. Many actinomycetes have ____________ aerial ________________. An aerial mycelium is a mass of _______________ which extend upward from the surface of the ____________________ (usually a nutrient agar).	18. diffusible spread out
20. Sometimes the aerial ______________ is one color and the _____________mycelium is another. Sometimes the actinomycete has no ___________ ___________________.	19. colored mycelium hyphae medium
21. Unfortunately _____________ differing in color from their parents are produced by _______________ mutation or by irradiation with _________________ light.	20. mycelium substrate aerial mycelium
22. The antibiotic pigments carefully elucidated include the red __________ and the yellow ___________ and __________________.	21. variants (mutants) natural ultraviolet
	22. actinomycins tetracyclines polyenes

---

23. Pigments produced by both actinomycetes and the bacteria are the ____________ and the ____________. Serratia marcescens is a ____________ and it produces the bright red pigment ___________________ but so do Streptomyces longispons ruber and Actinomadum maduarae which are _________________.

---

24. Production of antibiotics ________ useful as a major taxonomic criteria. Pigment production _______ useful as a major taxonomic criteria.

23. phenazines
phenoxazinones
bacteria
prodigiasin
actinomycetes

---

25. DNA (deoxyribonucleic acids) contain equimolar amounts of G (______________), C(____________), and of A(______________), and T (______________). One can express the composition of genetic __________ as the % of ______________ it contains.

24. is not
is not

---

26. Normore and Brown compiled _____________ DNA G & C %'s. Deley and later Yamaguchi compiled _______________ DNA G & C %'s.

25. guanine
cytosine
adenosone
thymine
DNA
G & C

---

27. Unfortunately DNA G & C % is not very useful as a ____________ tool. Besides it is a laborious task. But Table 1 does show a relationship between the ____________ _____________ of actinomycetes and their base ________________.

26. bacterial
actinomycetal

---

28. The cell wall of actinomycetes like bacteria contains a _______________, a mucopepticle layer. It is possible to test for the major _____________ of this murein layer. Tables II and III show these breakdowns, Thes authors contend that cell wall type is a more stable property than _____________________.

27. taxonomic
temperature requirement
compositions

---

28. murein
constituents
motility

---

29. Lipids are a heterogenous group of bio-chemicals. The simple lipids are composed of ____________ acids and the trihydroxyl alcohol ____________. These are called tri- ______________. The compound lipids are composed of long chain ____________ acids and one to three ____________ -hydroxyl alcohols. The derived lipids or complex lipids contain glycerol, fatty acids and a ____________ base. These are mainly phospholipids. All lipids may contain both saturated and ______________ fatty acids.	
30. Lipid patterns may be used to separate streptomycetes from ______________ and they characterize the genus __________________.	29. fatty glycerol glyerides fatty mono- nitrogeneous unsaturated
31. Type IV cell wall and Type A whole-cell sugar patterns are characteristic of _____________, ________________ and many _____________. Their ____________ represents an uninterrupted spectrum from mucoid bacteria to highly ______________ branched organisms bearing chains of ___________.	30. nocardiae Mycobacterium
32. Studies using lipid composition by Asselineau and Lechevalier show that it is possible to differentiate between the members of genus ______________ and genus _____________. The coryne forms ________ be distinguished by chemistry alone.	31. nocardiae mycobacteria corynebacteria morphology filamentous conidia
33. The suggested 'improved' classification of actinomycetes is found in __________________. Lechevalier avoids the __________ ________________.	32. Nocardia Mycobacterium cannot
34. Now you are to use Table V to classify a suspect bacteria. Here are the characteristics: (A) In the microscope the mycelia in the agar are fragmented. There is no evidence of an aerial mycelium nor are there any spores. (B) The chemical test for mycolic acid is positive; the cell wall is rich in meso 2, 6-diamino pimelic acid, arabinose, and galactose. (C) There is no sporangi; the mycelium divides perpendicular to the main hyphal axis.	33. Table V coryneform bacteria

35. Here is another suspect, classify it. (A) Cell Wall chemistry reveals only meso-DAP. (B) The mycelium grows in all directions and is not flat. (C) An analytical response for madurose is negative. (D) It was isolated from chicken manure.

ASK YOUR INSTRUCTOR AND/OR STUDENT TUTOR FOR THE CORRECT ANSWER AND REVIEW THIS EXERCISE IN PREPARATION FOR THE QUIZ TO FOLLOW LATER.

EM-11 THE ACTINOMYCETES

PACKET #5 NOMENCLATURE AND TAXONOMY OF ACTINOMYCETES - PROGRAMMED REVIEW

1. When and by whom was the term Actinomyces first used?	
2. In 1872, F. Cohn had found aerobic ray fungi which he called Streptothrix, but we now call these ____________.	1. Harz in 1877 gave them this name when he found 'ray fungi' in the pus of cattle which had lumpy jaw.
3. Almquist recognized that actinomycetes fall into two major groups, the ____________ and the ____________.	2. Nocardia
4. Produce a cover sheet for the Actinomycetes which includes the informtion on pages 62 & 63 which describe the actinomycetes as ____________.	3. anaerobes aerobes
5. Considering the key points on page 63 what did Krassilnokov suggest in 1964? ____________ ____________ ____________ ____________. He thought they were more closely related to ____________.	4. Eubacteria (true bacteria)
6. The historical schema for classifying actinomycetes are laid out on pages 64-72. Who are the famous early investigators? ____________, ____________ ____________. (Do you have these names on 3" x 5" index cards?)	5. That actinomycetes be placed between Schizomycetes & Hyphomycetes. (Our key - How to know plant families places them with bacteria.) Hesseltine placed them closer to fungi!
7. Note the great changes by 1963 when Kuster reorganized the order Actinomycetales. What new genus was proposed by Thirumalacher in 1955? ____________. What did Krassilnikov (1962) suggest? ____________ ____________.	6. Buchanan - 1917 Orskov - 1923 Jensen - 1930
	7. Chainia Actinopycinidium

8. Waksman considered Chainia, Actinopychidium, Streptoverticillium, Thermopolyspora. Microbiospora and many other genera to be _______________. Such genera were considered based upon ____________ characteristics and hardly sufficient to justify creation of new __________________. DO YOU SEE WHY Actinomycete Taxonomy is not complete in 1977?

9. Recently Cummins & Harris have suggested basing taxonomy of actinomycetes upon _______________ _______________ _________________. Their evidence very definitely places actinomycete in the order ___________________________.

8. invalid
secondary
genera

10. **In using** the Lechevalier Classification System note choices are: A or B; I or II; 1 or 2; a or b; a^{I}, b^{I} or c^{I}; a^{II} ......f^{II}; a^{III} or b^{III}. Study the table and be able to use it once given characteristics of an actinomycete.

9. cell wall structure
Eubacteriales

11. Jacob's classification of thermophilic actinomycetes is given. How do you determine if an organism is in Streptomyces or Micromonospora genera?

____

____

10. Pg. 69-72, Waksman

12. You are now to prepare a short essay on some problems concerning Actinomycete classification and identification. Consider (a) ease of obtaining data in most laboratories, e.g., cell wall composition; (b) time to grow; (c) media (consult pages 245-250 in Waksman); (d) saltation; (e) mutagenic agents; (f) phage action; (g) adaptation; (h) action of metabolic products on species. Read again Co-operative Taxonomy, page 7 in Sykes & Skinner.

11. Pg. 74, Waksman

WHILE UTILIZING THIS MODULE YOU SHOULD HAVE DEVELOPED OVER TWENTY KRITTER SHEETS ON ACTINOMYCETE GENERA INCLUDING DRAWINGS. SUBMIT YOUR BEST TWENTY FOR CREDIT.

EM-11 THE ACTINOMYCETES
END OF MODULE TEST

You may utilize THE FIELD IDENTIFICATION NOTEBOOK, TECHNIQUE SHEETS, DATA STORAGE DECK AND/OR 3" x 5" CARD FILE.

MATCHING:

1. _____ Rossi-Riccardo-Cholodny
2. _____ Orskov
3. _____ Erikson
4. _____ Rossi-Doria
5. _____ Miquel-Tsiklinsky
6. _____ Cohn
7. _____ Waksman
8. _____ Globig-Beijerinck
9. _____ Hiltner-Stormer
10. _____ Gratia-Dath

A. First to study actinomycetes in the air...found Streptothrix alba (now Streptomyces albus)....1891

B. Dean of U.S. Soil Microbiologists. The author of hundreds papers on actinomycetes. Author of section of Bergey's on actinomycetes classification.....1930-40's.

C. First actinomycete found; in tear duct of human eye....he thought it was a fungus....1875.

D. Contact slide technique for viewing microbes as they occur in soil or compost.....1927.

E. The first classification of actinomycetes on a morphological basis.....1923.

F. Discovered the peculiar symbiosis between the reduvid bug, Rhodnius prolixus and Nocardia rhodnii, the reproduction of the bug being dependent upon the actinomycete......1935.

G. The Thermoactinomyces of manures....the magic composters.....1879.

H. First quantitative estimation of actinomycetes in soil 1903.

I. First work on actinomycete-ANTIBIOTICS 1924-1927.

J. First soil actinomycetes.....up to 1 to 2 meters in soil profile....in river muds, the hay-infusions. 1888-1900.

ACTINOMYCETE MORPHOLOGY:

Produce drawings of five actinomycete genera showing aerial mycelium in red and substrate mycelium in black.

DESCRIBE HOW THE TECHNICIAN MAY PROVE THAT AN ISOLATE IS AN ACTINOMYCETE AND NOT A BACTERIA, FUNGUS, ALGAE OR SLIME MOLD.

EM-12 FERNS AND FERN ALLIES

PURPOSE: To acquaint the student with the ferns and their close relatives the horsetails, spikemosses and quillworts; those embryophytes which are more complex than mosses and reproduce by spores.

MATERIALS:

1. Fern Spore Germination Kit - (Utilize ordinary laboratory equipment).

2. Plant Press.

3. Fern Life Cycle: Carolina Biological Supply Do. - filmstrip and folder.

4. Fern and Fern Allies Slides. Carolina Biological Supply Co.

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EM-12 FERNS AND FERN ALLIES (cont.)

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EM-12 FERNS AND FERN ALLIES
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OBJECTIVES: To enable the student to:

1. Identify ferns and their allies.

2. Propagate these plants by spores, rhizomes or propagules.

3. Utilize these plants in the home, garden or in landscaping.

4. Understand their life cycle, ecology and function in the natural environment.

DATE STARTED: ________________

EM-12 FERNS AND FERN ALLIES — INSTRUCTION AND CHECK OFF SHEET

PACKET #1 - A FIELD GUIDE TO THE FERNS

Read pages VII-XV and 1-44 in Cobb's - A FIELD GUIDE TO THE FERNS. Note the extensive bibliography on pages 261-267, and the checklist for North America, pages 268-270. Take self-quiz. Submit Morphology of Ferns kritter sheet.

DATE COMPLETED: ________________
INSTRUCTOR SIGNATURE: ________________

PACKET #2 - THE FERN LIFE CYCLE

Read briefly the FERN LIFE CYCLE folder (Carolina Biological Supply Co.) and then utilize the film strip to follow the details of the cycle. Produce 'kritter sheets' on the Fern Life Cycle, Azolla sp., Salvinia sp., Marsilea sp. cinnamonea. It is not necesary to have sheets for extinct species, i.e. Tempskya and Osmunda pluma. Submit kritter sheets to instructor for evaluation and take self-quiz.

DATE COMPLETED: ________________
INSTRUCTOR SIGNATURE: ________________

PACKET #3 - MICROBIOLOGICAL SLIDES

View the slides and produce a kritter sheet for Pteridium aquilinum. Submit this sheet to instructor for correction.

DATE COMPLETED: ________________
INSTRUCTOR SIGNATURE: ________________

PACKET #4 - HANDBOOK ON FERNS

Read the HANDBOOK ON FERNS as edited by Helen Hall. Note that this unit applies to the Landscape Design Course also. Produce the required kritter sheets and take the self-quiz. Should you desire you may grow ferns from spores using the fern spore-growing kit.

DATE COMPLETED: ________________
INSTRUCTOR SIGNATURE: ________________

PACKET #5 -

Reproduce for your Field Identification Notebook the two charts from pages 42 and 43 of Cobb. Submit to your instructor.

DATE COMPLTED: ________________
INSTRUCTOR SIGNATURE: ________________

PACKET #6 - COLLECTING AND GROWING FERNS

From the general environment including artificial (i.e. greenhouses) collect the species of fern or fern allies. Attempt to obtain species which are representative of the eleven families described in Cobb. Place the completed kritter sheets in your Field Identification Notebook - in order of the chart in Packet #5. Submit your three least common finds as pressed preserved specimens on botanical sheets. Hand in all kritter sheets to instructor for credit.

DATE COMPLETED: ________________
INSTRUCTOR SIGNATURE: ________________

REQUEST END OF MODULE TEST.

TEST: ________________
DATE MODULE COMPLETED: ________________
INSTRUCTOR COMPLETED: ________________

EM-12 FERNS AND FERN ALLIES
PACKET #1 SELF-QUIZ

---

1. How many species of ferns including "rare ones", are found in our Northeast and Midlands of the U.S.A.? ____________

2. Are the ferns found in the U.S. also found in Europe? ____________

3. How many species of ferns and their allies are in the world? ____________

4. What problem exists in raising some ferns from spores? ____________

5. What are Cobb's major sources of nomenclature of ferns? Do you have them on Data Storage Cards? ____________

6. What is interesting about the Asplenium adiatum-nigrum found in Colorado?

____

7. What areas of research remain open concerning ferns and their allies?

a. ____________

b. ____________

8. Draw morphology page for F.I.D. notebook - page XX - (Opp. pg. 1) Include another page of description of parts. Hand in to instructor.

9. What are other names of rootstock? a. ____________
b. ____________ c. ____________
What are other names for the stalk? d. ____________
e. ____________. What are other names for leaf? f. ____________
g. ____________ h. ____________. What is another name for
the axis? i. ____________.

10. What is the problem taxonomically with young ferns? ____________

11. List the 'silhouette' groups used in Cobb's book under his group I.

IA ____________

IB ____________
IC ____________
ID ____________
IE ____________
IF ____________
IG ____________
IH ____________

12. List the groups found under Group II under leaf form.

IIA ____
IIB ____
IIC ____
IID ____

13. List the groups utilized in Cobb's third group.

IIIA ____
IIIB ____

14. What are groups IV & V? IV ________________ V ____________________

15. Where are the spikemosses and quillworts, described? What are the common names of the two species found most often? What form is found in more tropical areas? Produce 'kritter sheets' for S rupestriz and S. apoda. Hand in to instructor.

16. What are the order, family and genus of quillwort? How many species? What do they resemble?

17. What is the structure at the base of a quillwort? What is the term used to describe their spoon-shaped leaf bases? What are the female and male spores called?

18. By what are the sporangia encased? What feature is used to differentiate species? Draw the species of quillwort which may be found in New England on a F.I.D. sheet and hand into instructor.

19. Add notes to the cover sheets for F.I.D. notebook from general descriptions of ferns and their allies on page 41 of a FLORA OF NORTHERN NEW HAMPSHIRE.

20. What dirrectials between a cryptogram and a phanerogam?

PACKET #2 SELF-QUIZ

Draw on an 8½" x 11" paper the fern life cycle and label the following:

1. mature sporophyte
2. leaflet showing sori
3. cross-section of typical sorus
4. typical sporangium
5. a capsule bursting open
6. young prothallia
7. mature prothallium
8. antheridium
9. sperm
10. archgonium with egg
11. archegonium with zygote
12. sporophyte embryo
13. a sporophyte growing on gametophyte

Accompany the drawing with a written explanation of the cycle. Include information on time and size. Hand in to the instructor and discuss.

EM-12 FERNS AND FERN ALLIES NAME: ____________________

PACKET #4 SELF-QUIZ DATE: ____________________

FERNS

PART I CLOSED NOTES

MATCHING

1. _____ crozier
2. _____ ostrich
3. _____ Christmas fern
4. _____ hay-scented fern
5. _____ bulblet bladder fern
6. _____ grape ferns
7. _____ spleenwort
8. _____ walking fern
9. _____ curly-grass fern
10. _____ Tupper Hill cobble

A. LIMESTONE RIDGES: CREVICES

B. vegetative budding

C. grow symbiotically with microbes, cannot be moved far

D. Jersey pine barrens

E. fiddlehead

F. best hardy evergreen

G. large fronded, edible fiddlehead

H. can 'conquer' whole area

I. for lime-loving ferns

J. prefers dry locations - limey soil

PART II. METHODS OF REPRODUCTION: LIST FOUR

A. B.

C. D.

PART III. FERN TERMS: MATCHING

1. _____ prothallia
2. _____ spermatozoa
3. _____ sori
4. _____ rhizoids
5. _____ stipe
6. _____ frond
7. _____ epiphyte
8. _____ rachis
9. _____ rhisome
10. _____ dimorphic

A. fruiting body

B. primitive rootlike gametophyte structures

C. grows on other plants

D. frond 'petiole'

E. flat, heart shaped gametophyte

F. midrib of blade

G. horizontal, usually underground stem

H. having sterile and fertile fronds, different in appearance

I. a fern 'leaf'

J. male sex cells

WHEN COMPLETE HAND IN AND PROCEED TO PART IV.

PART IV (FERNS) USE YOUR F.I.D. NOTEBOOK FOR PLANTS AND TECHNIQUES AND YOUR DATA STORAGE CARDS FOR OTHER INFORMATION. USE PROPER KRITTER SHEETS FOR ANSWERING THESE QUESTIONS.

1. Describe five important references on ferns. Include the author, date, other editions, publisher, availability. What does the reference __________ include.

2. Describe completely the fern assigned (or one found on a field trip).

3. Explain with a drawing how to build a hobble and why one might be necessary.

4. Explain with a drawing how to grow ferns from spores.

EM-12 FERNS AND FERN ALLIES
END OF MODULE TEST

I. MATCH THE TERM IN COLUMN I TO THE PHRASE IN COLUMN II.

	I		II
1.	_____ fiddlehead	A.	a cluster of sporangia
2.	_____ pinnules	B.	elongated cells between epidermis and spongy mesophyll
3.	_____ stomata	C.	coverings over the sori
4,	_____ palisade layer	D.	female organs of gametophyte
5.	_____ sorus	E.	produce sperm
6.	_____ annulus	F.	fern bud
7.	_____ indusia	G.	found on lower epidermis of pinnules
8.	_____ prothallium	H.	[illegible]ckened lip cells of a capsule
9.	_____ archegonia	I.	primitive flat plate of cells which will develop into gametophyte
10.	_____ antheridia	J.	leaflets of compound leaves

II. MATCH THE FERN TO THE DESCRIPTION.

1.	______ Osmunda ferns: O regalis, O. cinnamona, O. claytoniana	A.	likes limestone; reproduces by pea sized bulblets
2.	______ Polystichum acrostichoides, Christmas fern	B.	National Arboretum in Wash. D. C.
3.	______ Matteuccia pensylvanica, Ostrich fern	C.	large ferns, easily grown in landscape plan
4.	______ Cystopteris bulbifera, Bladder fern	D.	the grape ferns
5.	______ Botrychium species	E.	has dimorphis leaves, edible fiddlehead
6.	______ Tupper Hill	F.	fiddlehead
7.	______ Fern Valley	G.	best evergreen hardy fern
8.	______ crosier	H.	fertilized fern megaspore
9.	______ zygote	I.	extinct Mesozoic tree fern
10.	______ Tempskya sp	J.	limestone cobbles

EM-13 LIVERWORTS

PURPOSE: To assist the student in recognizing, identifying and appreciation of the thalloid and leafy liverworts and the related hornworts.

MATERIALS:

1. The Liverworts: Carolina Biological Supply Co. filmstrip and booklet.

2. Slides of typical liverworts and hornworts - Carolina Biological Supply Co.

3. Bower, F.O. Primitive Land Plants. MacMillan & Co.

4. Bold, H. C. Morphology of Plants. Harper & Butlers.

5. Campbell, D. H. The Evolution of Land Plants. Stanford Univ. Press.

6. Conard, H. S. How to Know the Mosses & Liverworts. Wm. C. Brown Co. Dubuque, Iowa.

7. Frye, T. C. and Clark, L. Hepaticae of North America. Univ. of Wash.

8. Goebel, K. Organography of Plants, Expecially of Archegoniatae and Spermatophyta, Pt. II. Oxford Univ. Press.

9. Griffith, D. J. The Pyrenoid. The Botanical Review, Vol. 36, 29,

10. Haupt, A. W. Plant Morphology. McGraw-Hill Book Co.

11. Macvicar, S. M. Students Handbook of British Hepatics.

12. Scagel, R. F. et. al. An Evolutionary Survey of the Plant Kingdom. Wadsworth Pub. Co., Inc.

13. Schuster, R. M. Hepaticae of Central New York. American Midland Naturalist, Notre Dame, Ind.

14. Schuster, R.M. Liverworts of Minnesota and Southeastern Liverworts.

15. Schuster, R. M. Hepaticae and Anthocerotae of North America East of the 100th Meridian. 3 Vols. Columbia Univ. Press.

16. Smith, G.M. Cryptogamic Botany, Vol. II. Bryophytes and Pteridophytes. McGraw-Hill Book Co., Inc.

17. Parihar, N. S. An Introduction to Embryophyta, Vol I. Bryophyta. 4th Rev. Ed. Central Book Depot Allahabad.

EM-13 LIVERWORTS (cont.)

18. Smith, J. L. Liverworts: Pallovicinia and Symphyogyna and Their Conducting System. Iniv. of Cal. Press.

19. Steere, W. C. Liverworts of Southern Michigan. Cranbrook Inst. of Science.

20. Verdoorn, F. Manual of Bryology, Martinus Nijhoff. The Hague, Netherlands.

21. Wardlaw, C. W. Embryogenesis in Plants. John Wiley and Sons, Inc.

22. Watson, E. V. The Structure and Life of Bryophytes. Hutchinson & Co., Ltd.

OBJECTIVES: TO ENABLE THE STUDENT TO

1. Analyze the structure and function of liverworts and anthocerots.

2. Collect, store and preserve these plants.

3. Classify these bryophytes using spores, gemmae morphology and microsection.

4. Prepare environmental studies relating liverworts and anthocerots to other fauna and flora.

EM-13 & 14 LIVERWORTS AND MOSSES
CLASSIFICATION

PUT THIS CLASSIFICATION SHEET IN YOUR FIELD IDENTIFICATION NOTEBOOK UNDER THE SECTION ENTITLED MOSSES AND THE SECTION ENTITLED LIVERWORTS.

Mosses are of three distinct types:
- Musci (True Mosses)
- Hepaticae (Liverworts)
- Anthocerotae (Hornworts)

They are all very similar in regard to their structures and life history that the same terms are applied to most. The whole group has long been known as Bryophyta, and in other classifications are still known as this. They belong to the phylum of green land-plants, and are best characterized by their lack of the specialized water-conducting cells (tracheids and tracheae) which make possible the life of larger land plants. Mosses then classified as Atracheata (without tracheids) and the larger land-plants - Tracheata.

From this ATRACHEATA can be divided into:
1. Musci
2. Hepaticae
3. Anthocerotae

and to break it down even further,

Class Musci

Series 1 Sphagnobrya
  Order Sphagnales
    Family Sphagnaceae

Series 2 Andreaobrya
  Order Andreaeales
    Family Andreaeaceae

Series 3. Eubrya

Division I. Nematodonteae
- a. Peristome teeth made of several or many long cells lying lengthwise of the tooth.

Division II. Arthrodonteae
- a. Teeth with transverse lines of bars (or lacking).
- b. Each tooth made of the partition wall between certain cells.
- c. EXCEPTIONS: Buxbaumiaceae, Encalyptaceae, Splachnaceae
  1. Haplolepideae - single circle of peristome teeth, or various reductions of this.
  2. Diplolepideae - outer circle of hard teeth and an inner membranous set of segments and/or cilia, or various reductions of this plan.
     - a. Acrocarpi
       - i. archegonium and seta borne at tip of usually erect leafy stem.
       - ii. little or no midification of adjacent leaves.
       - iii, bud growing out below the 'flower' may give the seta the appearance of being lateral.

---

b. Pleurocarpi
  i. stems abundantly branching, creeping, with archegonia and seta borne in special lateral bud with leaves different from the vegetable leaves.

Class Hepaticae

Order Jungermanniales - leafy liverworts

Order Metzgeriales - thalloid liverworts with stalked capsules

Order Sphaerocarpales - tiny thallose forms with antheridia and archegonia in sacs

Order Marchantiales - spongy (air-filled) thallus, and tiny sporophytes borne on an umbrella- shaped receptacle or imbedded in the thallus

Class Anthocerotae

Order Anthocerotales - gametophyte is a green thallus or scale with no distinction of stem and leaf

Family Anthocerotaceae
Genus Anthoceros - sporophyte erect
Genus Notothylas - sporophyte short and horizontal

DATE STARTED: ____________

EM- 13 LIVERWORTS INSTRUCTION AND CHECK OFF SHEET

PACKET #1 -

Read the Carolina Biological Supply Compnay pamphlet which accompanies the filmstrip. Utilize the pamphlet and the filmstrip to discover what Liverworts are. Make up kritter sheets for Porella sp, Riccia sp., Conocephalum sp., Frullania sp., Lanularia sp., Sphaerocarpus sp., Ricciocarpus sp., Pallavicinia sp., Marchantia sp., and Anthoceros sp. When you see these in nature you will be able to complete these sheets. Utilize the accompanying classification scheme to place these sheets in the F.I.D. notebook in their proper position.

F. I. D. SHEETS: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #2 -

Read pages 14-16 in THE MOSSES AND LIVERWORTS by H. S. Conard. Do the programmed review. Collect a liverwort sample from the local environment; identify this sample at least to family; make up a herbarium sample (packet); and make up a kritter sheet for this sample. You are encouraged to identify more than one.

LIVERWORT SAMPLE: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #3 - MARCHANTIA SP.

Review slide set B5770, The Marchantia Life Cycle. Place the drawings on the Marchantia sp. kritter sheet. (You can use more than one sheet for each kritter).

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #4 - SPORE LIBERATION IN CRYPTOGAMS

Read the Oxford Biology Reader #49 - SPORE LIBERATION IN CRYPTOGAMS by C. T. Ingold. Request programmed review.

Set up Field Identification Sheets (similar to Figure 1 in reader), producing an 8½" x 11" sheet to show Bryophyte classification and another to show Pteridophyte classification.

KRITTER SHEETS: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

REQUEST END OF MODULE TEST.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

EM-13 THE LIVERWORTS
PACKET #2 PROGRAMMED REVIEW

---

1. Liverworts are green scales or ribbons lying on the __________ or ___________ in water. Some have stems with _____ rows of leaves and some of these have a third row called __________.	
2. Leaves of liverworts are ____________ in shape. Many species have a __________ at the tip of the leaf. The shape of the notch and of the two ____________ are important for identification. Sometimes there are more than one notch or _______ lobes. A liverwort leaf may be divided into __________________ rows of cells.	1. ground floating two underleaves
3. In identifying liverworts it is important to note how the leaves are ___________ to the stem, whether the leaf is simple or ______________ and whether the walls of the leaf cells are ___________ or thickened.	2. varied notch lobes two threadlike
4. The leaf is almost always attached ___________ to the stem. This means that one edge of the leaf is attached along the upper side of the stem, and the other along the lower. If the edge of the leaf that is attached to the upper side of the stem is also nearer to the tip of the stem it is called an ______________________ arrangement, and it seems that each leaf seems to ride up over the edge of the next leaf towards the tip of the stem. If the front edge of each leaf runs under the rear edge of the leaf next nearer the tip of the stem it is called a ______________ arrangement. Which arrangement is most common? ______________________________.	3. attached bilobed thin
5. A ________________ bilobed leaf is made in two lobes and these are ________________ close against each other. The smaller lobe may be flat and leaf-like or it may be formed into a hollow ____________,	4. obliquely incubous succubous
6. Cell walls may be equally thick or thin walled all around or they may be thickened in the corners of the cell to form triangular masses called ___________________.	5. complicate folded sac holding water
	6. trigones

7. All liverworts have round, oval or rod-shaped ______________. The round and oval capsules are _________-____________ and break into pieces or split into four spreading quarters discharging _____________ and spirally-banded threads called ______________. The ____________, the stalk of the capsule may be an ______________ long but quickly withers away.	
8. The capsule originates in the __________ as in *Musci*. The one or more archegonia are surrounded by a leaf-like sac, the ____________. The perianth is used for identification since it is long-lived and there are many kinds: smooth, triangular, ridged, plaited, etc.	7. capsules short-lived spores elaters seta inch
9. ____________ are leaves adjacent to the perianth They are often divided, lobed or ____________ even when the stem-leaves are entire.	8. archegonium perianth
10. _____________, oval or globular bodies containing sperm are borne in pits of the surface of the _________________ liverworts. In leafy liverworts they occur 1 to 3 or 4 in the ___________ of a leaf. Such leaves usually bulge out over the anterida and occur in a group of 6 - __________ along the stem.	9. Bracts toothed
	10. anteridia thalloid axil 12

EM-13 THE LIVERWORTS
PACKET #4 SPORE LIBERATION IN CRYPTOGAMS PROGRAMMED REVIEW

---

1. Dispersal is important for two reasons: maintenance and extension of ____________ spread throughout a population of ______________. This paper deals with land ______________, the plants which reproduce by spores rather than seeds. The 'non-land' cryptogams essentially mean _______________. The two major groups of cryptogams are the _________________ and ________________. Bryophyta include the class ______________ (liverworts) and the class ________________ (mosses). Pteridophyta is composed of order ________________ (club mosses), ______________ (Horestails and scouring rushes), and ___________________ the ferns.	
2. In the __________ wetness is needed for ______________ and dryness for ____________ ___________. Sporulation involves three phases: spore _________, ____________, and _____________. To obtain good dispersal ____________ must be at times of high ______________ at well above ground level.	*1. range genes cryptogams algae bryophytes pteridophytes Hepaticae Musci Lycopodiales Equisetales Filicales*
3. Best 'liberation' time is __________ in hot dry weather. Spore-producing structures include the capsules on tall ________________, for liverworts and ______________. Horsetails, and __________-________________ have cone-like structures perched high above the vegetative portion of the plant. Ferns have ____________ which are almost always erect.	*2. cryptogams fertilization spore dispersal liberation dispersal deposition liberation turbulence*
4. Liverworts mosses and anthocerots are non-____________, while Pteridophytes are ___________ plants with well developed water and food conducting systems. Spermatophytes are also _______________ plants. Algae are _________. Bryophytes have ____________ spores while Pteridophytes have rather _____________ spores.	*3. midday seta mosses club-mosses sporangia*
	4. vascular vascular vascular non-vascular tiny large

5. Spore release can be considered either _________, in which the plant provides the potential energy or _________________ in which the environment provides the energy.	
6. The first scientist to demonstrate the explosive force available to the Polypody ferns was __________. He used tiny water-air filled ______________. In the Polypodiaceae the ______________ cells are filled with water and the tension caused by drying causes splitting of the _______________. The annulus folds back.....further and further until the water exceeds a critical level, the water '______________'. The annulus snaps back and the ______________ are ejected into the turbulent air.	5. active passive
7. A discharge mechanism released by the rupture of _________________ water is also used by __________________ (spike-club moss), leafy ______________, and the thalloid liverwort _____________________.	6. Berthelot capillaries annulus stomium tension spores
8. NOTE: Cephaloria lammersiana and not Cephalosia bicuspidata is the species of _________________ liverwort found in Northern New England. This species sporulates with the aid of _______________ which fill the water and upon drying flailing both __________ and ___________ into the air.	7. tensile Selaginella liverworts Riccardia

NOTE: IF YOU DO NOT HAVE LYCOPODIUM CLAVATUM, EQUISETUM ARVENSE. DRYOPTERIS SPECIES AND CEPHALOZIA LAMMERSIANA IN YOUR FILED IDENTIFICATION NOTEBOOK ADD THEM NOW INCLUDING THE SPORE LIBERATION INFORMATION FROM THIS READER. DRAW THESE FREE-HAND WITH EXPLANATION.

9. How does sporulation in Marchants polymorpha differ from this act in leafy liverworts?	8. leafy elaters elaters spores
	9. hygroscopic movement of elaters. Elaters not discharged.

10. In Pellia sp. no active discharge is noticed but for spores to leave the ____________ a strong ____________ is required, The rare gasteromycete fungus Battarrea, the common slime mold genus ____________________, and most ____________ also have ___________ elaters. NOTE FIGURES 10 and 11 IN YOUR FIELD IDENTIFICATION NOTEBOOK. What is the common Pellia in New England?	
11. The common Mnium species in N. E. are M. ________________ and M. _______________. ILLUSTRATE THIS SPECIES AND INCLUDE DRAWINGS OF THE PERISTOME ACTION FOR THE TYPICAL MOSS. PREPARE SIMILAR SHEETS AND NOTES ON SPORULATION FOR Funaria americana and Polytrichum juniperinum.	10. elaters wind Trichia Equisetae hygroscopic Pellia epiphylla
12. Illustrate and produce Field Identification sheets for Frullania bolanderi and F. asagrayona. You may use one sheet as species are similar. These liverworts have __________-______________ elaters.	11. serratum orthorynchum (M. hornum common in S.U.S. and Europe) (F. americana common Penna. South)
13. Illustrate by drawings the ___________-_____________ action of a Sphagnum sp. Choose the common species S. magellanicum.	12. spiral-spring
14. Riccia, Marattia and Ophioglossum use _________ spore liberation. Animal or rain-splash may be necessary for _______________. Splash dispersal is important to thalloid liverworts for _________ dispersal. Draw Figure 20 on the Marchantia polymorphs Field Identification Sheet. What method is used for sperm dispersal? ______________________ ______________________ Note Figure 21 on Marchantia sheet	13. air-gun
15. Prepare sheets for Conocephalum conicum and Polytrichum commune noting method of sperm dispersal.	14. passive Riccia gemma *sperm are not spores... they are part of sexual cycle which occurs in wet weather and they swim.

EM-13 LIVERWORTS NAME: ______________

END OF MODULE TEST I GRADE: ________ DATE: ______________

USE ANSWER SPACES TO THE RIGHT.

1. The Atracheata are divided into (a) ______, (b) _____ and (c) ______. (Use common names)	1. a. b. c.
2. The ______________(Technical name) includes only one order and one family.	2.
3. When liverwort spores germinate the first stage is a photosynthetic _________________.	3.
4. All liverworts have round, oval, or rod-shaped (a)____________. Often these bodies split into (b)__________ spreading sections and discharge spores using spirally banded threads called (c)_____________.	4. a. b. c.
5. The famale portion of the liverwort is called the (a)____________ which is surrounded by a leaf-like sac the (b)______________. The leaves adjacent to the sac are also distinct and are called (c) ______.	5. a. b. c.
6. The male portion of liverworts is called an (a)_________. It is borne in (b) ________________ on Thallose liverworts and in the (c) _____________ of leaves on leafy forms.	6. a. b. c.
7. Which of the following is not a leafy liverwort? (a) Porella, (b) Frullania, (c) Bazzania, (d) Plagiochila or (e) Lunularia.	7.
8. The first plant in which distinct sex chromosomes were found was __________________.	8.
9. The technical name for the stalk of a mature sporophyte is a (a)__________. The technical name for the capping capsule is a (b)_____________.	9. a. b.
10. A mature (a)___________ has a pair of opposite notches which form leading edges of the new (b)______________________.	10. a. b.
11. In liverworts the(a)________________ is parasitic on the (b)__________________.	11. a. b.
12. Anthocerots resemble what kind of liverwort? What kind of bodies are contained in the cells of these creatures which are distinctive?	12. a. b.

---

13. The meristems of horned liverworts are (a) ___________. The colmnella is central core of the (b) _________________ generation.

13. a.
b.

14. Draw a succubous leave leafy liverwort stem.

14.

Draw a complicate bilobed succubous leaf, and label and explain.

Draw the life cycle of Marchantia in detail.

Draw the life cycle on Lunularia sp. (as it is in the U.S.)

EM-13 LIVERWORTS NAME: ______________
END OF MODULE TEST II GRADE: __________ DATE: ______________

USE ANSWER SPACES TO THE RIGHT.

1. There are two basic types of liverwort forms. 1. a.
They are (a) ______________ and (b) ____________. b.

2. The dominant phase of the life cycle is the 2.
_______________ which is haploid genetically.

3. The asexual structure which houses asexual spore- 3.
like disks is called the ____________________.

4. Which of the following is not a thalloid liver- 4.
wort? (a) Ricciocarpus, (b) Conocephalum,
(c) Frullania, (d) Lunularia, (e) Riccia

5. The product of fertilization in plants is a 5. a.
_________________. In a liverwort this stage is b.
short-lived and depends upon the ________________
as a source of food.

6. The mature Sporophyte of liverworts consists 6. a.
of two parts the ___________ and the _____________. b.

7. A mature gemma has a pair of opposite __________ 7. a.
which form leading edges of a new __________________. b.

8. Male organs on liverworts are called ___________, 8. a.
while female are called ________________________. b.

9. The beginning of the sporophyte generation occurs 9.
when the male sperm having passed through the neck of
the archegonium fuses with the egg to produce a
______________________________.

10. Horned liverworts belong to the genus ____________. 10. a.
They superficially resemble ____________ liverworts, b.
but the photosynthetic cells contain a large ____________ c.
and distinctive ______________ bodies. d.

11. Unlike other liverworts anthocerot sporophytes 11. a.
have a persistant _____________. The sporophyte also b.
has a central core of sterile cells which form a
_________________________.

12. Draw an incubous leaved leafy liverwort.	12.
13. Draw a typical thin-walled polygonal liverwort cell.	13.
14. Show a thick-walled cell with inward bulging trigones.	14.

DRAW THE LIFE CYCLE OF Conocephalum sp. Show all distinctive features. Use one half of the sheet.

DRAW THE LIFE CYCLE OF Anthoceris sp. in detail.

EM-14 MOSSES

PURPOSE: To reveal the world of mosses to the student of the environment. To know mosses as individuals and as an integral part of our endangered environment.

MATERIALS:

1. Moss Life Cycle. Carolina Biological Supply Co. - filmstrip and booklet kit.

2. Moss Life Cycle slides. Carolina Biological Supply Co. - slides of moss in microscopic detail.

3. Bold, H. C. Morphology of Plants. Harper & Brothers.

4. Bopp, M. Control of Differentiation in Fern Allies and Bryophytes. Ann. Rev. of Plant Physiol. 19, 365-377.

5. Clymo, R. S. The Growth of Sphagnum: Methods of Measurement. J. of Ecol. 58, 13-49.

6. Conard, H. S. How to Know the Mosses and Liverworts. Wm. C. Brown & Co., Dubuque, Iowa.

7. Dixon, H. N. and Jameson, H. G. Student's Handbook of British Mosses. (has American mosses as well)

8. Dunham, E. M. How to Know the Mosses. The Mosher Press.

9. Gilbert, O. L. Bryophytes as Indicators of Air Pollution in the Tyne Valley. New Phytology. 67, 15-30.

10. Gimingham, C. H. and Robertson, E. T. Preliminary Investigations on the Structure of Bryophyte Communications. Trans. British Bryological Society 1, 330-344.

11. Grout, A. J. Mosses with a Hand Lens. Ed. 3. Published by the author, Newfane, Vt.

12. Grout, A. J. Mosses with a Hand Lens and Microscope.

13. Grout, A.J. (ed.) Moss Flora of North America.

14. Hebant, C. Structure et Differentiation des Tissues Conducteurs dans le Gametophyte des Polytrichum Naturalia mon spel. Ser. Bot. 18, 293-97. (Good illustrations even if in French).

15. Koch, W. J. Plants in the Laboratory. The MacMillan Co.

16. Lacey, W. S. Fossil Bryophytes. Biol. Rev. 44, 184-205.

EM-14 MOSSES (cont.)

17. Strater, D. T. Bryophyte Ecology. Sci. Prog. London 58, 419-434.

__OBJECTIVES__: To enable the student to:

1. Compare morphological and functions of bryophytes.

2. Relate mosses to their close relatives the hepatics and psilophytes.

3. Collect, store and preserve mosses.

4. Classify an unknown moss using gross morphology, spores and microdissection.

EM-13 & 14 LIVERWORTS AND MOSSES
CLASSIFICATION

PUT THIS CLASSIFICATION SHEET IN YOUR FIELD IDENTIFICATION NOTEBOOK UNDER THE SECTION ENTITLED MOSSES AND THE SECTION ENTITLED LIVERWORTS.

Mosses are of three distinct types:
Musci (True Mosses)
Hepaticae (Liverworts)
Anthocerotae (Hornworts)

They are all very similar in regard to their structures and life history that the same terms are applied to most. The whole group has long been known as Bryophyta, and in other classifications are still known as this. They belong to the phylum of green land-plants, and are best characterized by their lack of the specialized water-conducting cells (tracheids and tracheae) which make possible the life of larger land plants. Mosses then classified as Atracheata (without tracheids) and the larger land-plants - Tracheata.

From this ATRACHEATA can be divided into:
1. *Musci*
2. *Hepaticae*
3. *Anthocerotae*

and to break it down even further,
Class Musci

Series 1 — Sphagnobrya
Order — Sphagnales
Family — Sphagnaceae

Series 2 — Andreaobrya
Order — Andreaeales
Family — Andreaeaceae

Series 3. — Eubrya

Division I. Nematodonteae
- *a. Peristome teeth made of several or many long cells lying lengthwise of the tooth.*

Division II. Arthrodonteae
- *a. Teeth with transverse lines of bars (or lacking).*
- *b. Each tooth made of the partition wall between certain cells.*
- *c. EXCEPTIONS: Buxbaumiaceae, Encalyptaceae, Splachnaceae*
  - *1. Haplolepideae - single circle of peristome teeth, or various reductions of this.*
  - *2. Diplolepideae - outer circle of hard teeth and an inner membranous set of segments and/or cilia, or various reductions of this plan.*
    - *a. Acrocarpi*
      - *i. archegonium and seta borne at tip of usually erect leafy stem.*
      - *ii. little or no midification of adjacent leaves.*
      - *iii, bud growing out below the 'flower' may give the seta the appearance of being lateral.*

---

b. Pleurocarpi
   i. stems abundantly branching, creeping, with archegonia and seta borne in special lateral bud with leaves different from the vegetable leaves.

Class Hepaticae

Order Jungermanniales - leafy liverworts

Order Metzgeriales - thalloid liverworts with stalked capsules

Order Sphaerocarpales - tiny thallose forms with antheridia and archegonia in sacs

Order Marchantiales - spongy (air-filled) thallus, and tiny sporophytes borne on an umbrella- shaped receptacle or imbedded in the thallus

Class Anthocerotae

Order Anthocerotales - gametophyte is a green thallus or scale with no distinction of stem and leaf

Family Anthocerotaceae
   Genus Anthoceros - sporophyte erect
   Genus Notothylas - sporophyte short and horizontal

DATE STARTED: ____________

EM-14 MOSSES INSTRUCTION AND CHECK OFF SHEET

PACKET #1 -
Review filmstrip - Moss Life Cycle and proceed to packet #2. Prepare kritter sheets for a typical Sphagum and a member of genus Polytrichum.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #2 -
Read "About Mosses", pgs. 1-5 in Conard's book THE MOSSES AND LIVERWORTS. Read THE WORLD OF MOSSES, by Bette Davis. Ask for programmed review. As in question #2 in programmed review prepare kritter sheet on the life cycle of a moss.

MOSS LIFE CYCLE: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #3 -
Utilize the slides of the Moss Life Cycle. Give microscopic detail to your moss life cycle notes.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #4 -
Read "Mosses" by E. V. Watson - Oxford Biology Readers #29. Utilize programmed review.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

Your kritter notebook should now contain notes on Sphagnum sp., Polytrichum sp., Mnium sp., and at least one other moss. You are encouraged to collect and identify others, but at least two others are required. Utilize the references from the Purpose sheet.

TWO UNKNOWN MOSSES: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

REQUEST END OF MODULE TEST.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

EM-14 MOSSES
PACKET #2 WHAT ARE MOSSES? *PROGRAMMED REVIEW*

1. Mosses do not have ______________ or ___________ . They are small plants 1/16" to ___________ inches tall. All mosses are _____________. They reproduce by _______________. When mature they propogate by the formation of a _________________ (which is a male and female germ cell fused together.)	
2. Put in your F. I. D. notebook a drawing of the life cycle of a moss. A spore swells with water, bursts its shell, and puts forth a slender, branching, many-celled green thread called a _______________, which looks like a green ___________________. Some parts of the thread are ______________ and have branches going down into the ground, which are colorless or __________________. On this 'thread' ____________ soon appear and each bud grows out as a leafy stem or flattened scale. It is anchored and fed by _____________________.	*1. flowers seeds 24 photosynthetic sporulating zygote*
3. The male germ cells are produced in oval sacs called _________________. The female egg is borne in the bottom of a long necked vase called an ______________. When the egg is ready the archegonium produces ___________ which attracts the sperm, and the sperm and egg join.	*2. protonema alga oblique brown buds rhizoids*
4. This new duplex cell remains in the ___________ while it divides into two, then 4, 8, 16....... and many cells. Slowly the ___________ developes with its _______________. 'True' mosses have capped archegonia. This cap is the ______________.	*3. antheridia archegonium sucrose (cane sugar)*
5. The foot, seta, and capsule compose the ______________ which is a diploid organism. Thalli are _____________ and have only one set of genes.	*4. archegonium seta (stalk) capsule spore calyptra*
6. The sporophyte is dependent upon the ___________________ (mother plant).	*5. sporophyte haploid*
7. The east coast of the U. S. ________ richer in mosses than our west coast. Most mosses grow among ___________________. The ________________ are devoid of mosses.	*6. gametophyte*
	7. is not trees prairies

E,-14 MOSSES
PACKET #2 WHAT ARE MOSSES? (cont.)

8. The most useful moss group is the ____________. Iowa peat moss, however is mostly ________________.	
9. The true mosses are in class ______________. The other Atracheata are the ____________ and ________________.	*8. sphagnum Drepanocladus*
10. The major series of Musci are: ______________, ________________, and ________________. The Eubrya are divided into two major divisions: the ___________ and the _______________. In other books these divisions are ORDERS. The Key to the major genera is found in Conard's book on pp. _____ to ______. An index and pictured glossary of terms is found in Conrad pp. ________ to ____________.	*9. Musci Liverworts Normworts*
	10. Sphagnobrys Andreacobrya Eubrya Nematodonteae Arthrodonteae 167-214 215-226

The text Mosses with Hand-Lens and Microscope is included as a major reference in this module. Read preface, introduction, classification and nomenclature, collection, preservation, mounting, manipulation, life-history, structure and bryological terminology.....that is.....pages (3) to 46.

Note key to sterile mosses on pages 403-407.

The World of Mosses by Bette Davis will prove useful as a review for the end-of-module test. Include all module material and the list of important works on pages 45 and 46 in Grout, 17 and 18 in Conard, on page 29 of Watson and 62 of Davis in the Info Retrieval Course.

EM-14 THE MOSSES
PACKET #4 MOSSES BY E. V. WATSON PROGRAMMED REVIEW

1. All mosses display the ____________ pattern of life cycle, in which a haploid ________________ alternates with the diploid ___________, which is concerned with _________________ production. This 'alternation of generation' concept was discovered by ___________________.	
2. All mosses have no ______________. Leaf structure is the most diagnostic way to identify mosses. Mosses are anchored by ______________, a system of branching threads. When a spore germinates a ________________, the predecessor to rhizoids, is formed.	1. diplobiont gametophyte sporophyte spore Hofmeister
3. The _____________ is a sac where male gametes are borne and its wall is _____ cell thick. ____________ are fairly uniform in most mosses.	2. petiole rhizoids protenema
4. Paraphysis are separate from _______________ and are chlorophyllatous.	3. antheridium one antheridia
5. The male gametes which the antheridia releases are drawn to the neck of the _____________. A rounded ____________ houses the ovum and is topped by a longish neck. In the neck, cells break down and allow the male _____________ to reach the egg.	4. antheridia
6. There are certain advantages to the way mosses sporulate. They are: (1) The plant is shielded from direct effects of ___________; (2) mutations that might be useful at a later date can be _________; and (3) there are increased chances of ______________ due to increased number of meioses due to postponement. This is due to alternating in successive generations of the haploid gametophyte and the diploid sporophyte.	5. archegonium venter gamete
7. When there is a haploid generation there is a union of ________ which forms a _______. It was __________ who, during the period 1849-56, determined how life histories of diverse plants could be compared with one another by the concept of the alternation of ________________.	6. mutation collected variation
	7. gametes zygote Hofmeister generation

8. Chromosomes were so named for the first time by ________________ in 1888.	
9. The sporophyte is an __________ generation concerned with spore production. Spore production should be viewed as a '____________ _______' which in degree is dependent upon the gametophyte.	8. Waldeyer
10. All mosses, morphologically, have a sporophyte that bears no ______________ or lateral _____________ of any kind. It is ellipsoidal and upon growth becomes _____________ and after several weeks it becomes clearly differentiated into a basal, penetrating __________________, a stalk like seta and a swollen green capsule.	9. asexual new plant
11. The female structure, the _____________, is of 'immense morphological significance'. This means that female structures are very useful in recognizing mosses, as well as other ____________________.	10. appendages organs cylindrical foot
12. One of the most important concepts to remember is that in mosses the plant that we see the most of ......the part with ___________, ____________, and rhizoid is the sexual or ___________________ generation.	11. archegonia Bryophytes
13. Dissect and draw informational data similar to Figures 1, 2, 3, 4, & 6. Key these sketches to a drawing of the 'moss' plant with the sporophyte on the gametophyte.	12. leaves stem gametophyte
14. In the center of the capsule runs the broad ______________. The delicate hood which protects the capsule 'greening' is the _____________. The 'set' of teeth which are so important in spore dispersal is the ______________. The protonema grows in two stages, the rich green _______________ and leaf initiator the ______________, It is at this early stage of the _____________ generation that most resembles an _______________________.	13. You will collect or be given a moss to identify and work with for this unit.
	14. columnella calyptra peristome chloronema caulonema gametophyte algae

EM-14 THE MOSSES — *NAME:* ______________

END OF MODULE TEST — *GRADE:* __________ — *DATE:* ______________

1. Where there is little soil, moisture, and only bare rocks and lichens the bryologist can expect to find members of genus ______________. A common fresh water (underwater) moss is ________________. The most common moss in New England is ____________________.	*1. a.* *b.* *c.*
2. The technical name for the leafy shoot which arises from the moss thallus is the ______________. Do mosses have vascular tissue? ________________ ____________________________________ ____________________________________.	*2.*
3. The typical moss leaf is how many cells thick? ____________. Is the mid-rib thicker? __________ The mosses have no true roots, but instead have ______________________.	*3. a.* *b.* *c.*
4. Male and female sex organs are called _____________ and _____________ respectively; they may occur on a ____________ plant or on ______________ plants.	*4. a.* *b.* *c.* *d.*
5. Each sperm parent cell gives rise to ____________ sperms. How many flagella on the sperms? ____________	*5. a.* *b.*
6. The mature female organ has three major parts, (a) ________________, (b) ________________ and (c) __________________________.	*6. a.* *b.* *c.*
7. The fusion of sperm and egg forms a ____________. This marks the beginning of the diploid or _____________________ generation.	*7. a.* *b.*
8. The moss sporophyte has three parts: (a) __________, (b) __________________ and (c) __________. The upper part (c) is covered with an old archegonial tissue called the (d) ______________. The operculum is part of the capsule and is essentially a (e) _________. Within any species the number of (f) ____________ is constant.	*8. a.* *b.* *c.* *d.* *e.* *f.*
9. When a moss spore germinates it produces a photosynthetic filamentous ______________. Some mosses produce asexual ____________________.	*9. a.* *b.*

EM-14 THE MOSSES
END OF MODULE TEST   GRADE: ______________   NAME: ______________
DATE: ______________

---

10. The most common bog mosses belong to order ______________, Family, ______________ and genus ______________.

10. a.
b.
c.

---

11. Land plants which have specialized water-conducting cells are called ______________. The most simple forms of these in New England are in the phylum ______________.

11. a.
b.

---

12. The three series of mosses are: (a) ______________, (b) ______________ and (c) ______________. The largest (c) are 'true' (d) ______________.

12. a.
b.
c.
d.

---

13. Hofmeister in about 1850 showed how the life histories of the most diverse plants could be compared using one major concept the ______________ ______________ ______________.

13. a.

---

14. Draw the gametophyte with its parasitic sporophyte showing all major parts.

EM-14 THE MOSSES
END OF MODULE TEST *GRADE:* ____________ *NAME:* ____________
DATE: ____________

OPEN NOTES: Draw the life cycle of the Mnium sp.

EM-14 THE MOSSES
END OF MODULE TEST PART II GRADE: ____________

NAME: __________________
DATE: __________________

PLACE ANSWERS IN SPACES PROVIDED AT RIGHT.

1. All mosses and liverworts are diplobiont. This means that a ______________ g_______________ alternates with _______________ s_________________ generation.

1 a.
b. g
c.
d. s

---

2. The sporophyte is an ________________ generation which produces spores. The distal portion of the sporophyte carries a delicate hood called the ____________________________.

2. a.
b.

---

3. The first phase of a moss protonema is the rich green ______________________. This is followed by the _____________________ which initiates buds to form the leafy shoots.

3. a.
b.

---

4. Four basic observations make possible the use of moss keys. These (a) general growth _________________, (b) leaf _______________________, (c) ______________ form and (d) detail of the _______________ teeth.

4. a.
b.
c.
d.

---

5. The main __________________ of a typical moss gametophone consists of leaves arranged ______________ around the stem.

5. a.
b.

---

6. In liverworts the rootlike structures are composed of how many cells? ________ In mosses these structures are called __________________ and are _______________ filaments.

6. a.
b.
c.

---

7. In a moss antheridia the undifferentiated sperm ___________________ cells are surrounded by a layer of __________________ jacket cells. Hairlike sterile structures in the sexual region are called ____________.

7. a.
b.
c.

---

8. The toothed structure in the female capsule region is called the _________________. The capsule has regions: the (2a) _______________, an outer sterile region; the (b) _______________ wall; a central strand; the (c) ____________ spore producing region; and a sterile basal region, the (d) ______________ (which is the upper region of the capsule stalk.)

8. a.
2a.
b.
c.
d.

EM-14 THE MOSSES NAME: ________________
END OF MODULE TEST II GRADE: ________________ DATE: ________________

---

9. Often the gametophyte reproduces asexually by means of ________________. Some mosses produce resting bodies called ________________.

9. a.
b.

---

10. The pale green stalk which develops from a Sphagnum gametophyte is called a ________________.

10.

---

11. Draw the following: (a) filiform moss leaf; (b) revolute leaf cross section; (c) single costa in leaf; (d) isodiametric cells; and (e) nitrate calyptra.

11. a.

b.

c.

d.

e.

---

12. The seta should be examined to see if it is (a) ________________, (b) ________________ and (c) ________________.

12. a.
b.
c.

---

13. The midrib of moss leaves are: (a) ________________ (b) ________________ or (c) ________________.

13. a.
b.
c.

EM-14 THE MOSSES *NAME:* ______________

END OF MODULE TEST II (cont.)GRADE: ______________ *DATE:* ______________

---

14. List ten important characteristics to observe which would prove useful in identifying mosses.	*14. a.* *b.* *c.* *d.* *e.* *f.* *g.* *h.* *i.* *j.*

EM-14 THE MOSSES
END OF MODULE TEST II (cont.) *GRADE:* ____________ *NAME:* ________________
DATE: ________________

OPEN NOTES: Draw the life cycle of a Polytrichum sp.

EM-15 ALGAE

PURPOSE: To familiarize the student with the algae, both procaryot and eucaryot.

MATERIALS:

1. LABORATORY SUPPLIES FOR PRODUCING SLIDES, TYPICAL STAINS, AND GROWTH MEDIA FOR ALGAE.

2. LIVE ALGAE

3. Blinks, L. R. Manual of Phycology. Chronica Botanica Co.

4. Blinks, L. R. Autotrophic Microoranisms. Cambridge Univ. Press.

5. Bracket, J. Biochemical Cytology. Academic Press.

6. Buetow, D. E. (E.) The Biology of Euglena, 2 Vols. Academic Press.

7. Chadefand, M. and Emberger L. Traite de Botanique Systematique. Tome I. Les Vegetaux non Vasculaire. Masson et Cie, Paris.

8. Chapman, V. J. Seaweeds and Their Uses. Methuen, London.

9. Dawson, J. A. How to Know Seaweeds. W. C. Brown Co., Dubuque, Iowa.

10. Egle, K. Encyclopedia of Plant Physiology. 5 (1).

11. Engler, A. Syllabus der Pflanzenfamilicn. 12th Ed. Bd. I. Gebrüder-Borntraeger, Berlin.

12. Fogg, G. E. The Metabolism of Algae. Methuen, London.

13. Fritsch, F. E. Structure and Reproduction of the Algae I & II. Cambridge Univ. Press.

14. Huber-Pestalozzi, G. Das Phytoplankton des Süsswassers. 4. Euglenophyceek. E. Schweizerbactsche Verlagsbuchhandlung Stuttgart.

15. Hutchinson, G. E. A Treatise on Limnology. Wiley & Sons, Inc.

16. Leedale G. F. The Euglenoids. Oxford Biology Reader, Oxford University Press.

17. Leedale, G. F. Euglenoid Flagellates. Prentice-Hall.

18. Leedale G. F. Euglenida/Euglenophyta. Ann. Rev. Micro. 21, 31-48.

19. Leedale, G. F. Observations on Endonuclear Bacteria in Euglenoid Flagellates. Ost. Bot. Z. 116, 279-294.

20. Lewin, R. A. Physiology and Biochemistry of Algae. Academic Press.

21. McDowell, R. H. Properties of Alginates. Alginate Indust., Ltd., London.

22. Olsen, R. A. and Engel, E. R. The Photochemical Apparatus; Its Structure and Function. Brookhaven Symposim in Biology 1958. Upton, N. Y.

23. Prescott, G. W. The Aquatic Plants and the Fresh-water Algae. Wm. C. Brown Co., Pub., Dubuque, Iowa.

24. Round, F. E. The Biology of the Algae. St. Martin's Press.

25. Rudnick, D. (Ed.) Cellular Mechanisms of Differentiation and Growth. Princeton Univ. Press.

26. Ruttner, F. Fundamentals of Limnology. Univ. of Toronto Press.

27. Smith, G. M. (Ed.) Manual of Phycology. Chronica Botanica.

28. Smith, G. M. Cryptogamic Botany. Vol. I. McGraw- Hill Bk. Co, Inc.

OBJECTIVES:

1. Relate algae to other micro- and macro-organisms.

2. Capture algae from aquatic or terrestrial environments.

3. Culture and maintain algae.

4. Stain or press algae for storage and study.

5. Identify algae.

EM-15 ALGAE INTRODUCTION AND CHECK OFF SHEET

INTRODUCTION - To the modern algologist or phycologist (algae studiers) the algae are a heterogeneous group of thirteen (13) phyla which provides a lifetime of work and infinite diversity. Much is known of them, but much more remains to be studied. They have an ancient history. Some of the earliest rocks contain their fossils. They are essential for man's existence for they provide oxygen for our breathing; use the carbon dioxide we expire; start the cycle of the food chain; provide food directly for our consumption; reoxygenate our polluted streams and rivers; and complete the cycle from sunlight to man. They live in the soil, in caves, in all bodies of water, on animals and plants and on land with lichens. They are fascinating to study and beautiful of form.

PACKET #1 - Read the preface, intoduction, and morphology chapter in Round's THE BIOLOGY OF ALGAE. Examine the prepared slides of typical algae which accompanies this module.
Take self-quiz, correct and submit to instructor for insertion in your folder.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: _______________

PACKET #2 - Read the HOW TO KNOW THE FRESHWATER ALGAE. Pgs. 1-24 inclusive. Note that in other packets marine and terrestrial algae are considered but that only freshwater forms will be collected and classified. Be sure to read and underline in your own key (if you do not have this key take notes). When you are ready for the programmed review request it. After the review request self-correcting quiz. This quiz will be retained in your folder.

DATE COMPLETED: __________________
INSTRUCTOR SIGNATURE: _____________

PACKET #3 - Read the Oxford Biology Reader #5 - THE EUGLENOIDS by G. F. Leedale. After doing so request the programmed review and prepare for the self-quiz. Take the self-correcting quiz and after correcting it hand in to instructor for retention in your folder.

DATE COMPLETED: ___________________
INSTRUCTOR SIGNATURE: _____________

PACKET #4 - Produce hanging drop and/or permanent slides of the algae which are available in the laboratory according to season. Utilize kritter sheets THE HOW TO KNOW KEY, and the Basic references available to aid in your analysis. Practice with a minimum of ten (10) species. Stain, cover and label slides and hand into instructor for review.

DATE COMPLETED: _________________________
INSTRUCTOR SIGNATURE: ________________

PACKET #5 - Utilize the soil algae method to grow algae from a solid environmental sample. Determine the algal count using the M-P-N method. Be sure to have instructor sign this progress sheet.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #6 - In this module not all of the book THE BIOLOGY OF ALGAE IS CONSIDERED. In other mpdules (CELLULAR CHEMISTRY, AQUATEIC ECOLOGY, TERRESTRIAL ECOLOGY & PROTOZOA) this book will further be utilized. However, the section on Economic aspects. Chapter 12; and Classification, Chapter 13 will be utilized and read. There is no programmed review for this unit. Cover sheets for Phylum CYANOPHYTA (pgs. 234-35), CHRYSOPHYTA, XANTHOPHYTA , HAPTOPHYTA, BACILLARIOPHYTA, CHLOROPHYTA, PRASINOPHYTA, EUGLENOPHYTA, DINOPHYTA, CRYPTOPHYTA, PHALOPHYTA, & RHODOPHYTA will be placed in the kritter notebook after being checked by the instructor. Include enough information to key to order. This will require thirteen (13) sheets on both sides. You may use these notes to complete the self-correcting quiz.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

TAKE END OF MODULE TEST.

RESULTS: ____________________

DATE MODULE COMPLETED: __________________

EM-15 ALGAE
PACKET #1 SELF-QUIZ

Complete the blanks: Write the answers on this sheet and then ask instructor for self correction.

1. Cryptogams and the Spermatophyta arose from primitive ________________.

2. Very few algae have complex thalli and only the most advanced have rudimentary ______________________ tissues.

3. Only the very advanced and most complex algae, the __________________ have multicellular sexual organs.

4. The simplest plants are classed by many taxonomists with bacteria in the Schizomycetes. These are the _________________________________.

5. All algae have ___________________-a.

6. All algae ultimately manufacture and store ___________________ and ___________________.

7. Non-motile unicells are termed _________________________.

8. Colonial forms are termed (a) ________________, (b) __________________ and (c) _____________________.

9. Draw a rhizopodial algae.

10. Draw a protococcoidal algae.

11. Wjat special feature characterizes the Silicoflagellineae?

12. A few algal forms have a small unbranched vesicle containing a central vacuole and chloroplast rich peripheral cytoplasm. This is the _________________ organization.

13. What two types of filamentous organization exist?

14. Flat foloise or tubular thalli are formed by the larger algae: this is the ____________________ organization.

15. In most colonial forms the cells are imbedded in _____________________.

EM-15 ALGAE
PACKET #2 HOW TO KNOW THE FRESHWATER ALGAE: G. W. PRESCOTT

---

1. The plants which are distributed over this globe as widely as bacteria are the ____________.

---

2. The brown, red, yellow, yellow-green and many green algae are found most commonly in the __________ environment.

1. algae

---

3. Blue-green algae are now classed as __________. They are called ______-________ because they require light and produce their own ____________ using sunlight. Blue-green algae used to be classed as ______________.

2. marine

---

4. Brown algae are classed as phylum or division ______________. Red algae as __________. Yellow-green algae belong to the ____________. Diatoms and desmids are classed as ___________.

3. bacteria
photo-bacteria
food
cyanophyta

---

5. Many phytologists class the various euglenoids amongst the algae. These are in phylum (or division) __________________. The protozoan-like algae, the crytomonads and chloromonads are classed in phyla ________ and ___________.

4. Phaeophyta
Rhodophyta
Chrysophyta
Pyrrhophyta

---

6. Those unacquainted with algae call the ubiquitous green pond-scums by local names like: __________, __________ and ______________.

5. Euglenophyta
Cryptophyta
Chloromonadophyta

---

7. The Prescott keys allow identification of 530 genera, but there is considerable ____________ among species within a ____________. The plant identified ________ match closely the illustration in the key.

6. water moss
frog-spittle
pond silks

---

8. One form of algae which can be identified without a microscope is the group called _______-worts. They belong to the Phylum ________, sub-phylum ______________, Order ___________, and Family __________. There are six _______ listed in this family.

7. variation
genus
may not

---

8. stone
Chlorophyta
Charophyceae
Charales
Characeae
genera

EM-15 ALGAE
PACKET #2 HOW TO KNOW THE FRESHWATER ALGAE: G. W. PRESCOTT (cont.)

---

9. The common fresh water red algae Batrachospermum vagum is one of the few large freshwater algae which are easy to identify without a ____________________. This species belongs to Phylum ___________________, Order ___________________, Family ___________________.

READ PAGE 165 AND CAPTURE A SAMPLE FOR YOUR OWN STUDY.

10. The blue-green mucilage covered colonial algae Nostoc sp. is now called a ____________-______________. In this text it is in Phylum _________________, Order ___________________, and Family _________________.

READ PAGE 264 AND THEN SEE IF YOU CAN CAPTURE N. parmelcides OR N. commune IN A STREAM OR ALPINE MEADOW.

11. Some genera of unicellular algae are being used for the ______________ and ________________ of "biologicals". Biologicals include: ________________ growth promoting __________________ and growth inhibitors.

12. Sewage oxidation ponds depend upon algal ________________ and their production of the gas _______________ for reaeration. Of course such lagoons also depend upon _______________ currents for reoxidation.

13. The largest marine algae are Phasophytes called _____________________. In the Pacific Ocean are found the giant ________________ kelps which are commonly __________ feet long. They may grow to __________________ feet.

14. Some references would call the yellow-green chlorophyll bearing algae Synura and Dinobryen _______________. When we study protozoans we shall see these "algae " again for zoologists (zoologists) class them as ___________________.

9. microscope
Rhodophyta
Nemalionales
Batrachospermaceae

10. photobacteria
Cyanophyta
Nostocales
Nostocaceae

11. assay
detection
vitamins
hormones

12. photosynthesis
oxygen
wind (atmospheric)

13. kelps
Macrocystis
100
700

14. protozoans
animals

15. USE OF THE KEY: All the genera of North America ________ included in this key. Genera of algae ________ world-wide in distribution. There is ____________ route through this key to the same conclusion.	
16. This key is arranged such that at each junction the investigator has two paths from which to choose one. This key is called a ______________ key. It may be necessary in some cases (when in doubt at a junction) to ______________________.	15. are not are more than one
17. Of all the characteristics _________________ causes the most problem in identifying algae. The analyst must use more than one _________________ in attempting to identify algae.	16 dichotomous backtrack
18. List some of the habitats of common algae. Where are the rare algae often found? ____________ ______________________________ ______________________________ ______________________________	17. color characteristic
19. The biota found at high water level on a beach beneath the _____________ is termed the ________________. It is composed of _____________, ______________, ____________________, and ____________________.	18. submerged grasses rush culms sticks aquatic plants wet stones wood outcrops deep in wood undersides of cliffs and waterfalls beaches near high water, but under the sand. squeezed sphagnum moss
	19. surface psammon algae protozoans rotifers copepods

EM-15 ALGAE

PACKET #2 HOW TO KNOW THE FRESHWATER ALGAE: G. W. PRESCOTT (cont.)

20. Nitella is a green algae of large size. Often other algae grow ______________ this plant. Duckweed (_____________ ________________ binomial) or the floating liverworts ____________ _________________, or _______________ ________________ often contain algae which are _______________________.	
21. Some algae attach to other plants and are called _______________, while others actually enter the host and are semi-parisitic or ________________. Indian turnip or _____________ or _______________ (Genus) often have spots on their leaves caused by the parisitic algae _____________________.	20. within (inside) Lemna trisula Riccocarpus natans Riccia fluitans endophytic
22. Animals often have algal ____________ on the skins, hides or shells. The snapping turtle harbors ________ ___________, a wing gilamentous algae. Red snow is caused by ________________ ____________________ which although a green algae of sub-phylum __________________, order ________________, Family _____________________ contains the red carotenoid pigment. What other species are formed in blue, green, red, or yellow snow? ______________________ ____ ____.	21. epiphytes endophytes Jack-in-the Pulpit Arisaema Phyllosiphon
23. Although plankton nets may be used for collecting algae and other aquatic plants and animals (see Dept. Supplies) nature provides a 'living' net in the plant ___________________, the ______________-wort. _________________ are their favorite catch.	22. colonies Basicladia Chlamydomonas nivales Chlorophyceae Volvecales Chlamydomonadadese haematochrome Scotiella Ankistrodesmus Raphidonema Mycanthococcus dinoflagellates
24. Prepare on separate card boards descriptions of the phyla described on pages 15-18, placing the cards with tabs into the Environmental Field Identification Notebook. These basic characteristics should be committed to memory.	23. Utricularia bladder Desmids
25. Place the algae given into the correct phyla using the keys on pages 19-21.	24. and 25. Submit sheets and answer key to instructor or student tutor

EM-15 ALGAE

PACKET #2 HOW TO KNOW THE FRESHWATER ALGAE SELF-CORRECTING QUIZ.

---

1. 'Water blooms' are the result of an ______________________________.

2. Name two freshwater algae readily visible without a microscope; common names: ____________________ ____________________.

3. The longest algae is the sea algae ______________________________.

4. Some algae are articularly animal-like. Name two: ________________ & ______________________________.

5. The 'pond silks" are in genus ______________.

6. Does the key consider all genera of algae? ____________________.

7. What basic characteristics can be most troublesome or confusing to the student? ____.

8. Name some places where you might expect to find algae. ____________ ____.

9. What is the psammon? ______________________________

10. What higher plant species contain endophytic algae? Do you have these on kritter sheets? ______________________________ ____.

11. What causes 'red-snow'? ______________________________ ______________________________.

12. Desmids abound in what local habitat? ____________________.

13. The bladders of what plant often are filled with algal forms? ________ ____.

14. To study ________________ it is necessary to have a clear and unobstructed view of their frustules. These algae are particularly abundant in Lake ______________.

15. Live single-celled algae are (a) ______________, (b) ______________ and (c) ________________.

17. Use of the Synopsis of the Algal Phyla (pages 19-21) allow placement of an algal sample into one of the nine ______________________.

18. The brown seaweeds of the ocean are technically called ______________.

19. An obscure and little understood group with only a few genera and species is the ______________________.

20. A single-celled, motile, protozoanlike organism with two laterally inserted flagella of unequal length is most likely a ______________.

EM-15 ALGAE
PACKET #3 THE EUGLENOIDS

READ: The Euglenoids by Gordon F. Leedale (Oxford Biology Reader) and then do this programmed review for more understanding.

---

1. The unicellular organisms at the base of the plant and animal kingdoms include pigmented forms that swim by lashing ______________. These are the ___________ (Phylum Protozoa, class , Phytomastigophorea). These are the only organisms that _____________ like plants but are classified among the _____________ by zoologists.	
2. The phytoflagellates are divided into ______________ orders and some are colorless such as the order ______________. These orders are related to the pigmented ones and are thought to have lost their ___________________ secondarily.	1. flagella phytoflagellates photosynthesize animals
3. The phytoflagellate orders are distinguished by differences in _______________ (chlorophylls, carotenes, and xanthophylls): chemistry of a cell wall (if present); number and form of ______________ ; methods of _____________; and any morphological specializations.	2. ten Euglenida chloroplasts
4. In botanical classification the Euglenoids appear within the _______________ as the class _____________, phylum Euglenophyta.	3. pigments flagella reproduction
5. Euglena is important as a _______-____________ of biological teaching and a key organism in research on __________________, chloroplast structure and physiology, nucleic acid, ___________, lipid metabolism ______________, photoreception and flagellar activity. The species most often used is ___________ ______________________.	4. algae Euglenaphyceae
6. There are about _____________ different euglenoid genera ranging from __________ to 500 μ in length. Many cells are elongated and either ____________ or flattened, others are fusiform, spherical, oval, ______________ or leaf-like. Colacium is the only euglenoid with more than one _________________.	5. plant-animal photosynthesis nutrition respiration Euglena gracilis
	6. forty 10 cylindrical spiralled cell

7. Euglenoid genera and species are distinguished from one another by number of ____________ and attitude during swimming; prescence or absence of ____________ and their number, shape and size; form of pyrenoid, presence or absemce of an ______________, photoreceptor, ingestion organelle, and envelope; and ____________ morphology.

---

8. *Khawinea* and *Cyclidiopsis* have eyespots but no ______________________________.

7. flagella
chloroplasts
eyespot
cell

---

9. It is thought that most euglenoids have _______________ flagella per cell and that the uniflagellate genera will soon be shown to have two by __________ _____________. A few parasitic species have ___________ than two flagella and a few ____________ forms have no ________________.

8. chloroplasts

---

10. In *Euglena*, *Astasia*, *Trachelomonas*, *Phacus*, *Rhabdomonas*, and *Menoidium* there is only ________ emergent flagellum which is ___________ all the time. Two emergent flagella are found continually moving in _____________ and ____________. All of these euglenoids swim in an eratic and _________ way.

9. two
electron microscopy
more
rhizopodis
flagella

---

11. *Heteronema*, *Peranema*, *Notosolenus*, and *Entosiphon*, ______________ euglenoids; ___________ flagellum is held out straight in front of the cell with just the tip mobile or with a ________ action part of its length. Their swimming is ____________ or ______________. The second flagellum trails ____________ and apparently acts as a nonpropulsive shed or rudder.

10. one
mobile
Eutreptia
Distigma
jerky

---

12. Common to all euglenoids is a unilateral array of __________ hairs on the emergent flagella and shorter hairs and fibrous bands. These hairs _______________ down propulsion.

11. colorless
one
snapping
smooth
swift
posteriously

---

12. fine
slow

---

13. The orange red __________ (stigma) of __________ euglenoids and some colorless ones contain B-carotene and other __________ pigments. The eyespot is not a specialized region of a __________.

---

14. A swelling near the base of the main flagellum of all euglenoids with eyespots is currently thought of being a __________, possibly containing __________ as a sensitizer. The organism can judge the intensity and direction of the light source and swim away from the bright light-__________- and from darkness to dim light - __________.

13. eyespot
green
carotenoid
chloroplast

---

15. Euglenoid cells have a __________ (screw) symmetry seen most clearly in the __________. The whole pellicular complex lies internal to the plasma __________ and is part of the living cell. The pellicle complex consists of pellicular __________, __________ bodies and bundles of __________.

14. photoreceptor
lactoflavin
negative phototaxis
positive phototaxis

---

16. The possible function of muciferous bodies is supplying the grooves mucilage to be used as a __________.

15. helical
pellicle
membrane
strips
muciferous
microtubules

---

17. Euglenoid movement is merely an expression of cytoplasmic __________ within the confines of an elastic __________ which continually recovers to a definite __________.

16. lubricant

---

18. __________ is the invagination of water rather than solid materials, __________ is the regulation of their osmotic pressure within the cell.

17. flow
pellicle
shape

---

19. Among the type of euglenoids that have small discoid __________ without pyrenoids are typical for Phacus, __________ and Cepocenclis and are the type found in many algae and nearly all higher __________.

18. Pinocytosis
Osmoregulation

---

19. chloroplasts
Klebsiella
plants

---

20. Large ______________ with naked or paramylon-sheathed pyrenoids are characteristic of certain species of __________________, Trachelomonas, and Colacium.

---

21. Chloroplast ribbons radiating from a paramylon centre are typical for __________________ and a few Euglena spp.

20. chloroplast
Euglena

---

22. ___________ is the carbohydrate reserve of colourless euglenoids as well as green euglenoids.

21. Eutneptia

---

23. Not only are there ___________, ____________, and ____________ species in nutrtional versatility but some can switch from one type of nutrition to another.

22. Paramylon

---

24. _____________ ______________ is used in hospitals as an assay organism for colbalamin, lack of which causes ___________ ____________ in man.

23. photosynthetic
saprophytic
phagotrophic

---

25. The nuclear envelope does not break down in Euglenoid ______________ and may represent an _____________ stage of classical mitosis.

24. Euglena gracilis
pernicious anaemia

---

25. mitosis
evolutionary

EM-15
PACKET #3 SELF-CORRECTING QUIZ A

MATCHING

1. _____ phagotroph
2. _____ most research done in Euglenoids using this kritter
3. _____ only Euglenoid with more than one cell
4. _____ positive phototaxis
5. _____ adenosene triphosphate (ATP)
6. _____ lactoflavin
7. _____ pinocytosis
8. _____ phytoflagellate pigment
9. _____ osmoregulation
10. _____ negative phototaxis

A. swim from darkness to dim light
B. invagination of water
C. xanthophyll
D. swim away from bright light
E. control of salt concentration in the cell
F. Peranena
G. Colacium
H. necessary for flaggelar activity
I. Euglena gracilis
J. sensitizer in photoreceptor

EM-15

PACKET #3 SELF-CORRECTING QUIZ B

---

1. _____ phagotroph
2. _____ photoreception
3. _____ pyrenoid
4. _____ fusiform
5. _____ organelle
6. _____ phototaxis
7. _____ osmoregulation
8. _____ phytoflagellate pigment
9. _____ euglenoid storage carbohydrates
10. _____ stigma

A. cigar or spindle shaped

B. regulation of osmotic pressure within cell

C. light sensitive directional control

D. carotene

E. any intercellular separate structure

F. paramylon

G. the process of light interception and control

H. pigmented micelle

I. voracious predator

J. orange-red eyespot

SOIL ALGAE

Algae are widely distributed in the surface layers of soil and even deep into porous soils. They vary in size and shape from microscopic single celled organisms to filamentous multicellular forms several inches long. Algae may rest in a form which is low in photosynthetic pigmentation, but when exposed to light they once again show they are photoautotrophic.

Reference should be given to John (1942), Lund (1947), Pringsheim (1946), Durrell (1959), Bristol (1920), Fletcher (1948), Tchan (1959), Willson (1957) Wilson (1937) and the other text material available in this package.

The SOIL BLOCK method will be used here to enumerate species and the MPN (MOST-PROBABLE-NUMBER) method will be utilized to estimate the number of algal cells per gram dry soil.

SOIL BLOCK METHOD:

MOIST CHAMBER: USE THREE (3) petri dishes (or other containers provided). Fit a filter paper to the bottom using scissors. Sterilize at 15 psi for 15 minutes.

PROCEDURE: From the desired field location cut small cubes or segments of soil crust about 1 cm deep and 3 cm in diameter. Place each of three (3) samples in separate chambers and a fourth in a weighed chamber for determination of dry weight and % moisture. Label one of the three samples for MPN Test. Into another chamber pipette sterile water; into the last chamber Willson-Forest enrichment solution. Use enough water or solution to moisten, NOT FLOOD. Incubate at room temperature in diffuse sunlight. At weekly intervals for four to eight weeks use a sterile spatula to remove crumbs to a clean glass slide. Examine and identify akgae (or other kritters). Note if growth is better in water or enriched solution. Record any other observation of ecological nature.

Dry the one sample in an oven at 110° C for two days and determine % moisture. Note that final MPN results are algal cells/gram dry soil.

M-P-N- METHOD:

WATER BLANKS: Using the 100 ml bottles provided prepare one bottle with about one dozen glass beads and 95 ml of distilled, deionized (d.d.) water and five other bottles with 90 ml of d.d. water and no beads. These may be prepared well ahead of a test run and stored. STEAM STERILIZE.

INCUBATION CHAMBERS: For each soil sample to be examined prepare nine (9) incubation chambers, each containing 20 ml of substrate solution (below). Sterilize containers by autoclaving at 15 psi for 15 minutes.

SUBSTRATE SOLUTION: (WILLSON-FOREST SOLUTION) (should be already prepared)

1 gram $NaNO_3$

1 gram K_2HPO_4

0.3 grams $MgSO_4 \cdot 7\ H_2O$

0.1 grams $CaCl_2 \cdot H_2O$

0.1 grams NaCl

trace $FeCl_3 \cdot 6\ H_2O$

1000 ml of distilled water

PROCEDURE:

DILUTION SERIES: Transfer 10 grams of moist soil to a sterile glass beaded water blank using waxed paper and brush. Cap. Shake vigorously for 15 minutes. Remove 10 ml using sterile pipette; transfer to unbeaded water blank. This establishes a 10^{-2} dilution. Similarly transfer from this bottle using another sterile pipette to produce 10^{-3}, 10^{-5} and 10^{-6} dilutions.

Start with highest dilution 10^{-6} and using the same 1 ml pipette transfer to three sterile incubation chambers from that dilution. Move up the series with three plates for each dilution until 10^{-6} dilution to obtain 9 incubation chambers.

Incubate at room temperature in diffuse sunlight for four weeks.

At weekly intervals during incubation and terminally, observe the inoculated containers for green, blue-green, or other colored growths. Such growths usually appear as surface rings or pellicles. If it is not clear from the macroscopic appearance that the culture contains algae (some pigmented growths may be due to photosynthetic bacteria), transfer a portion of the growth to a microscope slide by means of a bacteriological transfer loop, and make a direct microscopic examinstion of the wet mount. Bacteria, if present, will commonly appear as small rods, 1 micron or less in diameter and usually 2 microns or less in length. They may be either motile or non-motile. Algae are appreciably larger in size, usually ten (10) microns or more in diameter, and more commonly non-motile. They will frequently appear as multi-cellular filaments of spherical or short cylindrical cells.

EM-15 ALGAE
PACKET #5 (cont.)

Record the number of cultures that are positive for algae at each dilution. Find the MOST PROBABLE NUMBER of algae in the initial soil sample.

DILUTION		10^{-4}	10^{-5}	10^{-6}
CHAMBERS	1			
	2			
	3			

RESULTS: Estimate algal cells/gram dry soil.

Report genera and/or species found.

NOTE: You may capture a slime mold, bacteria, actinomycete, or fungus which can be used in other modules. Take advantage of stray kritters captured.

EM-15 ALGAE
PACKET #6 SELF-CORRECTING QUIZ

---

1. What are four major products derived from algae? ____________________, ____________________, ____________________, ____________________.

2. The Phaeophyta: Laminaria, Asochylium, Macrocystis, Ecklonia, and Durrillea are sources of ______________________________.

3. What are the enemies of Macrocystis? ______________________________ ____

4. What forms of alginic acid are soluble? ______________________________ ____

5. What is alginic acid and its derivatives used for? ____________________ ____

6. What are the algal sources of Carragheen? _______________ _______________ and ________________________

7. Describe agar. ____ ____

8. Gelidium, Campylaephora, Pterocladia, Gracilaria, Eucheuma, Furcellaria and Phyllorphora are sources of: ______________________________.

9. A sizing agent and glue is made frim Gliopeltis furcata called by the Japanese ____________________.

10. What two elements were first discovered in seaweed in 1812 and 1826? ______________________________ and ________________________

11. Kieselgurh is a mineral product which once was ____________________. Another name for this is ____________________. The major use for diatomaceous products is in ______________________________. What cathedral dome was made in 532 A.D. of lightweight diatom brick? ______________________________

12. Some algae are used directly as fertilizer. Name three forms. ____________________, ____________________, ________________________.

13. Describe how seaweed can be used as fodder. ________________________ ____

14. 'Cachiyogo' is a dried and salted form of ________________________

15. Tse-Ko-Tsoi is made from Digenia simplex. It is an ____________________.

16. What algae probably decreases bacterial growth in water works filters? ________________________ ________________________.

17. Red-tide is caused by a ______________________________.

18. The algae Microcystis, Aphanizomenon and Anabaena are all __________________. If they are in the bloom stage they can kill what animals? __________________ ____.

---

19. What possible future process using sewage and algae may be tried? What genera would one expect to see in a sewage lagoon? ____________________

____

____

____

20. Where is Nostoc communa grown as a soil conditioner? ______________

____

EM-15 LAGAE
END OF MODULE TEST

I. MATCHING

__________	autogamy	A.	a polysaccharide composed of linked glucose residues
__________	axenic culture	B.	surface layer of the cell
__________	glucan	C.	uptake of large molecules by membrane invagination at the cell surface
__________	osmotroph	D.	fusion of two nuclei that are the division products of a cell
__________	periplast	E.	cultivation of bacteria free cultures
__________	phagotroph	F.	dense proteinaceous region of chloroplast stroma which accumulates reserve carbohydrates
__________	pinocystosis	G.	capable of extending thin filaments of cytoplasm from cell
__________	pyrenoid	H.	a nucleolus that persists and divides during mitosis
__________	rhizopodial	I.	organism that ingests food
__________	endsome	J.	organism that absorbs nutrients in soluble form only

II. USE YOUR KRITTER NOTEBOOK TO INDICATE ORDER OF EACH OF THE FOLLOWING GENERA.

GENERA	ORDER
Anabaena	____________________
Dinobryon	____________________
Eudorina	____________________
Volvox	____________________
Chlorella	____________________
Ulothrix	____________________
Chara	____________________
Euglena	____________________
Chilomonas	____________________
Nitella	____________________

III. MATCH THE ALGAE TO ITS PRODUCT

1. ________ Laminaria-Ascophyllum
2. ________ Choridrus crispus
3. ________ Eucheuma - Gelidium
4. ________ Gloiopeltis furoata
5. ________ Diatoms
6. ________ Durvillea-Pachymenia
7. ________ Sargassum
8. ________ Ulva
9. ________ Digenia simplex
10. ________ Chlorella

A. funori
B. alginic acid
C. Kieselguhr
D. fertilizer
E. carrageenin
F. sea lettuce
G. fodder
H. medicine, Tse-Ko-Tsoi
I. chlorellin antibiotic
J. agar

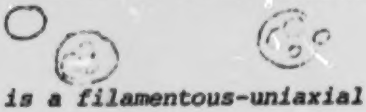
IV. MORPHOLOGY: PLACE THE WORD TRUE OR THE WORD FALSE IN THE SPACE PROVIDED.

1. _______ Non-motile unicellular algae are called PROTOCOCCOIDAN
2. _______ 'Amoeba-like' algae are called FLAGELLATE forms.
3. _______ The colonial habit is achieved in TETRASPORAL forms by the aggregation of the products of cell division within a mucilage mass.
4. _______ The red algae show the most complex system of reproduction in the plant kingdom.
5. _______ The simplest plants are the blue-green algae which have no sex cycle.
6. _______ The main biochemical pathways in algae are dramatically different than pathways in higher plant forms.
7. _______ This unicellular form is termed RHIZOPODIAL.

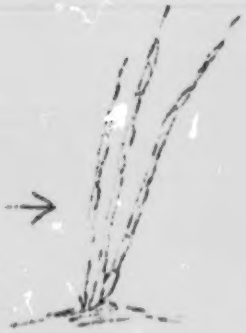
8. ________ This unicellular form is termed PROTOCOCCOIDAL.

[illegible] - 15 ALGAE
END OF MODULE TEST (cont.)

9. ____________ This unicellular form is PROTOCOCCOIDAL.

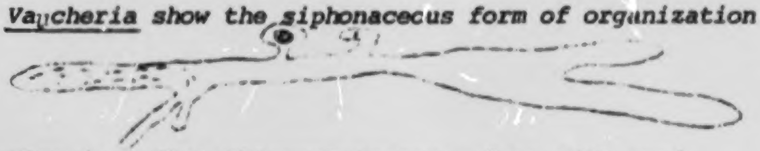


10. ____________ This is a filamentous-uniaxial algal form.



11. ____________ A heterocyst is an asexual spore.

12. ____________ Vaucheria show the siphonaceous form of organization shown below.



13. ____________ Ulva is a flat Chlorophytaceous algae with parenchymatous organization.

14. ____________ Marl and other calcereous deposits may result from accumulation of dead stoneworts.

15. ____________ Nitella like Chara can be identified by its habit of encrusting itself with lime.

16. ____________ Chlamydomonas have been known to cause 'red-snow'.

17. ____________ Volvox cannot stand high nitrogen levels in water and avoids areas where eutrophication might occur.

18. ____________ Scenedesmus species often appear in laboratory cultures and in the psammon.

19. ____________ Chlorella species often inhabit protozoan and sponges.

20. ____________ Spirogyra can be identified without mature zygospores.

V. MAKE A HANGING DROP SLIDE OF THE UNKNOWN (UNKNOWNS) AND IDENTIFY AT LEAST ONE TO GENUS LEVEL.

EM-16 PARASITOLOGY

PURPOSE:

To assist the student in gaining an in depth understanding of the cause, symptoms, ecology and treatment of parasitic disease. To study the protozoan and metazoan creatures which can adversely affect man's environment

MATERIALS: TEXTS

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EM-16 PARASITOLOGY (cont.)

OBJECTIVES: To enable the student to:

1. Recognize the adult and larval stages of paraites.

2. Collect, preserve, stain or otherwise treat specimens.

3. Identify parasitic protozoa, nematodes, cestodes, trematodes and arthropods.

4. Suggest methods of eradication or control of these parasites.

5. Relate parasitological knowledge to environmental assessments.

DATE STARTED: ____________

EM-16 PARAISTOLOGY

INSTRUCTION AND CHECK OFF SHEET

PACKET #1 - BASIC PARASITOLOGY

Read Chapters 1 through 4, 13, 14 and 15 in BASIC PARASITOLOGY where required and Chapters 5 and 6 - LUMEN DWELLING PROTOZOA and MALARIA. Utilize HOW TO KNOW THE PROTOZOA and other references available for kritter sheets. A filmstrip is available to match Chapters 1-6, 13, 14 & 15 in Markell & Vogt. Slides are available to match these parasites. Request programmed review and after completing that request End of Packet Quiz.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #2 - BLOOD AND TISSUE DWELLING PROTOZOAN

Read Chapter 7 and the sections in Markell & Vogt and other references in which techniques are discussed. Utilize filmstrip and programmed review. Prepare kritter sheets and technique sheets where necessary using slides available in laboratory. Take end of packet quiz.

KRITTER SHEETS: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #3 - THE TREMATODES

Read Preface, page 1-43 and practice using KEY TO TREMATODES by Stewart C. Schell - HOW TO KNOW THE TREMATODES. Read Chapter 8, pages 150-186 in Markell & Vogt. Produce kritter sheets of the many examples shown in both texts. Upgrade your technique sheets. Take the end of packet quiz, using the F.I.D. sheets prepared.

KRITTER SHEETS: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #4 - THE CESTODES

Read Preface, Introduction and pages 1-19 in THE TAPEWORMS by G. D. Schmidt and Chapter 9, pages 187-215 in Markell & Vogt. Produce outline of classification, drawings of general morphology and basic life cycles for F.I.D. notebook. Take end of packet quiz.

CLASSIFICATION: ____________
MORPHOLOGY AIDS: ____________
KRITTER SHEETS: ____________
DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #5 - THE NEMATODES

Read Chapter 10 and 11, pages 216-274 in Markell and Vogt. Develop F.I.D. sheets and technique sheets. If you have notes from The Nematode module they may be used and augmented. Complete end of packet quiz.

DATE COMPLETED: ____________
INSTRUCTOR SIGNATURE: ____________

PACKET #6 - ARTHROPODS
Read Chapter 12, pages 275-293 in Markell & Vogt. Develop F.I.D. sheets. There is no end of packet quiz in this packet.

KRITTER SHEETS: ____________________
DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

REQUEST END OF MODULE TEST.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

EM-16 PARASITOLOGY
PACKET #1 - BASIC PARASITOLOGY TERMS AND PROCEDURES: PROTOZOOLOGY: LUMEN DWELLERS AND MALARIANS

It would be helpful to read the material once-over and then to use the filmstrip and programmed review. "Remember to keep kritter sheets on all new creatures encountered. Utilize Chapters 1-6 and 13, 14 & 15.

---

1. Despite antibiotic drugs, DDT, insecticides and antiparasitic agents diseases caused by protozoan, ________________ and ____________________ parasites are still prevalent. Laboratory technicians able to ______________ such parasites are few. Physicians, medical technologists and ________________ health officials must cooperate to control these diseases.

---

2. The important Journals of Parasitology include: The Annual Review of _________________; The Medical Letter on Drugs and _______________; Tropical ______________ Bulletin; and The ________________ ______________ Journal of Medicine. ARE THESE JOURNALS STORED IN YOUR DATA STORAGE SYSTEM? Note these journals on page 4 also.

1. helminthic
arthropod
identify
public

---

3. The only class of protozoa which contains nothing but parasitic forms is the ________________. Specialized attachment organs in the form of _______________ and ________________ are present in parasitic flatworms. Most free-living nematodes are barely ________________ as adults.

2. Medicine
Therapeutics
Diseases
New England

---

4. The most common and widespread type of protozoan parasitic injury is that brought about by ________________ with the vital processes of the host, through the action of ________________, excretions or other products of the parasite.

3. Sporozoa
suckers
hooks
visible

---

5. Typical reactions to parasites include: ________________ caused by secretions and excretions e.g. Fasciolopsis buski; ____________ of the cell wall, e.g. proteolytic enzymes destroy intestinal wall by Entamoeba histolytica. ________________ of intestine by Ascaris or other roundworms. __________________ can be caused by hookworms which especially drain the host of iron. Megaloblastic anemia is the loss of vitamin _____.

4. interference
secretions

---

5. toxicity
erosion (destruction)
Obstruction
Anemia
B_{12}

---

6. Common stains for parasitic amoeba and protozoa include: ______________, ______________ and ______________. Which is the best? ____________.

---

7. What methods are used to concentrated cysts and ova? ______________________ and __________________,

6. Gram
Lugol
D'Antoni's
MIF (Methiolate-iodine formaldehyde)

---

8. You have found heliminth ova in a well-stained iron-hematoxylin mount. What do you consult to determine the species of parasite? _________________.

7. sedimentation
flotation (usually zinc-sulfate)

---

9. Be sure to place Figure 5 on your *E. histolytica* kritter sheet. The cysts are recognized due to their ______________ cyst wall. Cysts contain from one to _____ nuclei. The main habitat of the trophozoites is the large _______________ where it multiplies in the mucosal _____________. One major test on live amoeba is the _____________ test. Motility is progressive and directional. Unfortunately there is no 'characteristic' nuclear __________________ for any species of Entamoeba. Do you have the summary table on page 14 in your I.D. notebook?

8. Key to Helminth Ova page 27-28.

---

10. The prevalence of amebic infection, as of most ________________ diseases, varies with the level of __________________ and is generally higher in the tropics and subtropics then in the _____________ climate. Dietary ________________ often play a role in __________________ of infection.

9. hyaline
four
intestine
crypts
motility
morphology

---

11. The most dangerous carrier is the ____________ asymptomatic 'cyst- ___________'. A person with acute dysentery is of _____ significance in _________________ of the disease. Cysts can be killed by heating to ___________ ^{o}C, by _________-chlorination and by adding iodine to water.

10. enteric
sanitation
temperate
considerations
severity

---

11. chronic
passer
no
transmission
55
super

---

12. Two other strains or species of Entamoeba are E. histolytica var. ______________ and E. ________________. E. hartmanni is smaller and very much like E. histolytica but ingests only __________ and is more ________________. Cysts are less then ten _________ in diameter. The nonpathogen, E. coli, can be distinguished because it does not ingest _________ cells, its movements are ____________, and slow action of its haline _________________.

---

13. Two parasitic Entamoeba species are ___________ and _________________. There are several other common intestinal amoebae. These include Iodamoeba ________________, Endolimax __________________, and Dientamoeba _____________________.

12. Lavado
    moshkovskii
    bacteria
    rounded
    microns
    blood
    sluggish
    pseudopodia

---

14. Some amoebae are symbionts which if they multiply too quickly can become _______________ parasites. One known pathogenic amoeboflagellate is ____________. It alternates between _____________ form and a form having two ______________. The environmentalist must be aware of this disease. It commonly is contracted by young people who swim in ____________ or ______________ water or ___________ ____________. These pathogenic or commensal organisms may be grown on __________-nutrient agar upon which bacteria have been spread.

13. polecki
    gingivalis
    butschlii
    nana
    fragilis

---

15. Some protozoans found in the intestine are true flagellates These include _____________ lamblia; ____________ mesnili, _____________ hominis, Trichomonas ______________, Enteromonas ________________, and Retortamonas ________________. These species are diagnosed by trichrome staining of their intra-______________ fibrillar ___________________________.

14. opportunistic
    Naegleria
    amoeboid
    flagella
    fresh
    brackish
    swimming pools
    non

---

15. Giardia
    Chilomastix
    Enteromonas
    vaginalis
    hominis
    intestinalis
    cytoplasmic
    structures

---

16. Draw typical cysts and trophozoites of the species above on your kritter sheets. Submit for review. Produce a table of ten matching boxes to show comparative morphology on a separate sheet.

---

17. The only ciliate to parasitize man is __________ coli. The three sporozoans of importance to man are the Coccidians: ___________ belli and I. hominis and the cat intestine ciliate Toxoplasma _______________. The predominant malarial parasite in most of the world is _____________ vivax. In blood smears both the stages in the ___________ cycle of the parasite and sexual _______________ will be seen. A ________________ follows the somewhat synchronous rupture of the majority of the infected cells. NOTE: 'Vivax' means bizarre or highly irregular, a term well suited to the protozoan since during the _____________ phase it is mobile and changes shape within the red blood cell host. Especially diagnostic of P. vivax and P. ovale infection are ______________ dots.

16. SUBMIT KRITTER SHEETS AND COMPARISON SHEETS TO INSTRUCTOR.

---

18. Tropical Africa especially West Africa, is infested with Plasmodium ______________. Similar to P. vivax in schizogony it has typically 4 to 12 _______________, rarely 12-18, but the infected cells are ______________ and ______________. Margins of infected cells are often ________________ and the cells distinctly _______________, ovoid or irregular in shape. P. malariae, another malarial parasite, has a lower incidence than P. ___________ or P. _________________. The cytoplasm shows no ________________ dots but rather a fine 'dusting' called ______________ stippling. P. falciparum may prove to belong in genus ___________________.

17. Balantidium
Isopora
gondii
Plasmodium
asexual
gametophytes
paroxysm
amoeboid
Schüffner's

---

19. P. falciparum seems to invade _____________ ages of red cells ________________; P. vivax invade only ____________________, while P. malariae attacks ___________________ cells.

18. ovale
merozoites
enlarged
pale
ragged
elongated
vivax
falciparum
Schuffner's
Ziemann's
Laverania

---

19. all
indifferntly
reticulocytes
aging

20. Some of the diseases associated with *P. falciparum* are: ________ ________; ________
________: ________ ________
________ ________; ________ ________;
________ ________ ________;
________ ________; ________
________ ________ and ________
________.

20. cerebral malaria
malarial hyperpyrexia
bilious remittant fever
dysenteric malaria
algid malaria syndrome
blackwater fever
acute renal failure
pulmonary edema

NOW ASK FOR END OF PACKET QUIZ.

EM-16 PARASITOLOGY
PACKET #1 - END OF PACKET QUIZ

I. TRUE-FALSE

1. _______ The sickle cell trait is not inherited by results from poor nutrition.

2. _______ High protein diet is a major cause of development of intestinal protozoa infection.

3. _______ Primary infection by Leishmania will confer a degree of immunity to reinfection.

4. ______ Immunity to Trypanosoma lewisi may be developed by exposing the host to dead trypanosomes.

5. ______ Dexamethasone has proved effective in the management of edema of the brain occuring with cerebral malaria.

6. ______ Relapse commonly occurs with falciparum malaria.

7. ______ There is a danger when using antimalarial drugs during pregnancy.

8. ______ Schüffner's dots appear on a patient's skin when quotidian malaria has been contracted.

9. ______ Human malarial parasites were first actually seen in 1880 and their life history not understood until 1900.

10. ______ Plasmodium ovale has only been known since 1912. It now has spread throughout South America and Mexico.

II. MATCHING: TECHNICAL TERMS

1.	______	premunition	A. having both male and female reproductive organs.
2.	______	definitive host	B. the complex chemical which makes up Arthropods body coverings.
3.	______	hermaphrodite	C. the sucking lice
4.	______	Acanthocephala	D. true bugs, including wingless bedbugs
5.	______	chitin	E. resistance to hyperinfection
6.	_______	Anoplura	F. more than one host, but this host must support the parasite during its reproductive cycle
7.	______	Heteroptera	G. endoparasitic thorny-headed worms
8.	______	reduviids	H. Fleet's phospho-soda or Epsom salts

9.	_____ Navy Short Method	I. for permanent stained slides
10.	_____ purgation	J. cone-nosed bugs

III. PARASITE, HOST AND SYMPTOMS: MATCHING

1.	_____ Pneumocystis carinii	A. trophozoites have four pairs of flagella; two nuclei in anterior portion
2.	_____ Entamoeba gingivalis	B. non-pathogenic flagellate protozoan; lemon-shaped cysts. Curved cytostomal fibril
3.	_____ Entamoeba histolytica	C. infection in males asymptomatic but commonly caused vaginal discharge in females
4.	_____ Iodamoeba butschlii	D. the predominant malarial parasite in most parts of the world
5.	_____ Giardia lamblia	E. one of the sporozoans found in man; once thought rare; no effective treatment to this usually mild disease
6.	_____ Chilomastix mesnili	F. commonly attacks the compromised host. Grocott's methenamine-silver stain.
7.	_____ Trichomonas vaginalis	G. no host outside man; invades mouth, has no cyst stage; transferred by direct contact. Often found in pyorrheal pockets between teeth and gums. Will ingest leukocytes.
8.	_____ Balantidium coli	H. Buffalo-skin; Dyak ulcers, hepatic infection, pulmonary amebiasis; best test-indirect hemagglutination and gel-diffusion preciptin.
9.	_____ Isospora belli	I. non-pathogenic common inhabitant of digestive tract. Like Endolimax nana and Dientamoeba fragilis this amoeba is cosmopolitan and non-treatable.
10.	_____ Plasmodium vivax	J. the only ciliate to infect man; lumen dwellers; ingest bacteria; will penetrate intestinal mucosa to cause ulceration.

EM-16 PARASITOLOGY
PACKET #2 - BLOOD AND TISSUE DWELLING PROTOZOANS

1. The family Trypanosomidae, includes the __________, the flagellated blood eaters. The primitive form of this group is represented by __________. In the genus *Trypanosoma* the form is very modified having not only a __________ but an undulating __________. In some minute parasites the flagella, the __________ membrane and the __________ are lost and the protozoa are elliptical to round, have an internal __________ race, a __________-plast, and a nucleus. This last form is the __________ form.	
2. The three forms of *Trypanosoma* are the __________, __________ and __________. In all forms the flagella arises from the __________. All probably evolved from __________ parasites. They usually change in form when they invade a new host.	1. hemoflagellates *Leptomonas* flagella membrane undulating fusiform flagella Kineto leishmaial
3. African sleeping sickness is caused by members of genus __________, Gambian or West African __________ sickness is caused by *T.* __________. The native game animals contract a mild disease from *T.* __________. The carrier is usually the __________ fly, *Glossina* __________. During the incubation period typanosomes may be recovered from the 'trypanosome __________' and from then on in the blood. Later glands are involved which swell in what is called __________ sign. Late in the development of the disease pressure on the palm of the hand will produce sharp pain a short time __________ the removal of the pressure. This is __________ sign.	2. leishmanial leptomonal typanosomal blepharoplast insect
	3. *Trypanosoma* sleeping *gambiense* *brucei* tse-tse *palpalis* chancre Winterbottom's after Kerandel's

---

4. Control of West African sleeping sickness involves destruction of their ______________ places, or eradication of the flies Glossina ________________ or G. ____________________ with insecticides. Treatment is by ____________________, Mel B, or melarsen oxide complexed with ______________________.

---

5. Eastern and Central African forms of trypanosomiasis is spread by the intermediate host Glossina __________________. The etiologic agent is T. __________________. A diagnosis between East and West diseases is usually made on geographical grounds, but there are areas where all forms exist such as __________________. CNS invasion occurs very rapidly in the __________________ or East African infection. The wild or domesticated animals provide a _______________ for continuous infection. The drug of choice is ________________. It is toxic to many individuals so that the other drugs ___________________ and ________________ may have to be tried.

4. breeding
palpalis
tachinoides
melarsoprol
dimercaprol

---

6. An asymptomatic trypanosomal infection occurs in South America caused by T. __________________. It is transmitted by the bite of the reduviid bug Rhodnius _______________. Chagas disease is also spread by the ______________ bug, Panstrongylus __________________. Here the etiologic agent is T. ___________________________.

5. morsitans
rhodesiense
Uganda
Rhodesian
reservoir
Suramin
melarsoprol
pentamidine

---

7. Typical symptoms involve the formation early in the disease of erythematous indurations known as __________________, facial edema called __________________ sign, general malaise chills, high fever and a rash which is not painful on the chest or ____________________. Most diagnostic are ______________________________ changes.

6. rangeli
prolixus
reduviid
megistus
cruzi

---

7. chagomas
Romaña's
abdomen
electrocardiographic

---

8. The reduviids are also known as ______________-______________ bugs or _______________. They are widespread in the ________________ and do occur in the ____________________. In this age of travel the disease has on occasion spread to central __________ _____________. It has a large potential for future infestation. The only known treatment is with ___________________.	
9. The leishmanial diseases are thought to be caused by two species of __________________. The dermatotropic form is caused by *L.* ________________ and the visceral form, widely known by its Indian name, Kala-azar, *L.* ________________. Leishmaniases are transmitted by various species of ____________ for the most part of genus _____________________.	8. cone-nose triatomids Americas U. S. North America Bayer 2502
10. Another rather benign infectious protozoan is named after the animal in which it was first found, The North African rodent, the ______________. It runs through its whole coccidian life cycle in ________________ or other Felidae, but will on occasion develop in any ________________. The binomial name is ____________________.	9. *Leishmania* *tropica* *donovani* sandflies Phlebotomus
11. Toxoplasmosis occurs in a wide variety of both ________________ and herbivorous mammals and ___________________. Eating of infected _________ is often the means of infection, but even ___________________ are known to contract this disease. Treatment of toxoplasmosis is a combination of _______________ and _____________________.	10. gundi cats vertebrate *Toxoplasma gondii*
12. Pulmonary infection may be caused by ____________ *carinii*. Usually it attacks domestic and ____________ animals, but in recent years it has been found to be _________________ or the result of the use of _____________________ therapy. The drug of choice is _______________________.	11. carnivorous birds meat vegetarians pyrimethamine trisulfa-pyrimidines
	12. *Pneumocystis* wild congenital immunosuppressive pentamidine

13. Texas cattle ______________ and ____________ jaundice of ________________ are caused by sporozoans of genus ____________________. Infection is spread by ________________. Although rare babesiosis should be suspected in individuals with _______________ illnesses if organisms resembling _______________ falciparum are recovered in blood smears. Two drugs are used: ________________ and ___________________.

14. COMPLETE THE BINOMIAL:

Endolimax ________________________
Giardia __________________________
____________________________ vivax
____________________________ palpalis
____________________________ donovani

15. Give disease causing:

Gundi cat fever ______________ ____________
vaginal trichomoniasis ___________________
____
amoebic dysentery ___________ ____________
Gambian sleeping sickness _______________
____
Dermatotropic Leishmaniasis ______________
____

13. fever
malignant
dogs
Babesia
ticks
febrile
Plasmodium
chloroquine
pentamidine

14. nana
lamblia
Plasmodium
Glossina
Leishmania

15. Toxoplasma gondii
Trichomonas vaginalis
Entamoeba histolytica
Trypanosoma gambiense
Leishmania tropica

EM-16 PARASITOLOGY
PACKET #2 END OF PACKET QUIZ

MATCHING: TECHNICAL TERMS

1. _____ febrile		A. test-complement fixation using T. cruzi antigen
2. _____ transplacental		B. sign: typical in African sleeping sickness
3. _____ hydrocephalus		C. flies, transmit trypanosomiasis
4. _____ jaundice		D. caused by members of genus Naegleria
5. _____ Montenegro		E. sign: unilateral palpebral edema caused-by T. cruzi
6. _____ Machado-Guerreiro		F. old age and/or invalid
7. _____ tse-tse		G. enlarged skull filled with fluid, typical with Toxoplasmosis
8. _____ Kerandel's		H. yellowing of skin associated with falciparum malaria when bilious remittent fever stage is reached
9. _____ meningoencephalitis		I. a test involving interdermal injection of killed suspensions of leptomonads
10. _____ Romaña's		J. from female to young in womb

EM-16 PARASITOLOGY
PACKET #3 END OF PACKET QUIZ

I. FILL IN THE BLANKS:

The trematodes or ______________ represent a class of animals in the Phylum ____________________. This phylum contains all the _____________. The excretory or osmoregulatory system is composed of ________________ cells, tubules and an excretory ______________. The internal organs are embedded in ______________ tissue which develops from mesoderm. Most species sexually are ________________. The Phylum contains three classes, the free-living flatworms, Class _______________; the flukes, Class _______________; and the tapeworms of Class _________________________. The animals in these last two classes are all ____________________. The common planarian belongs to Class ________________, Order _______________. The other fresh, brackish or salt water free-living classes are __________, _______________, _______________, and ______________. The flat worms of Class ________________ are without digestive systems having a ____________ for attachment to host tissues and body of __________________. Those parasitic flatworms which have no cilia in the ______________ stage, a well developed ________________ tract and attachment organs are in Class ____________________. There are three subclasses: ___________, ___________ and _________________. The first two are called 'monogenetic' flukes since they attack only one host. They are usually _________________ on skin or gills of fish. The subclass Aspidogastrea are distinct in having a dorsal _____________________ containing internal organs and a ventral adhesive disc. They are internal parasites of clams, mussels, fishes and turtles.

II. SHOW THE LIFE CYCLE OF A DIGENETIC TREMATODE. USE AN 8½" x 11" KRITTER SHEET SO THAT YOUR CORRECTED CYCLE CAN BE PLACED IN YOUR KRITTER NOTEBOOK.

III. MATCH THE TREMATODE TO ITS HABITAT:

1. _____ Philophthalmus
2. _____ Acetodextra
3. _____ Nagmia & Probolitrema
4. _____ Collyriculum
5. _____ Allocreadium neotenicum
6. _____ Loxogenes
7. _____ Proterpmetra dickermani
8. _____ Unionidae family
9. _____ Nanophyetus salmincola
10. ____ Prosthogonimus & Parorchis

A. encysted in skin of birds
B. encysted in pairs in duodenum of frogs
C. in larvae and adults of diving beetles
D. bursa Fabricii and oviducts of birds
E. naso-lacrimal duct, conjunctiva and nictitating membranes of birds
F. in the coelom of cartilaginous fishes
G. larvae and adults develop in the same snail
H. in the pericardial cavity, kidney, or gill lamellae of freshwater clams
I. carry the salmon poisoning organism Neorickettsia helminthoeca; life cycle involves fish-eating mammals, a snail and salmon
J. in the swim bladder of bony fishes

MATCH THE TREATMENT TO THE PARASITE:

1. ____ hexylresorcinol & tetrachlcroethlene
2. ____ tetrachloroethylene
3. ____ chloroquine-Bithionol
4. ____ Bithionol
5. ____ emetine-HCl
6. ____ potassium antimony tartrate
7. ____ chloroquine-pentamidine
8. ____ Pentostam
9. ____ melarsoprol-Lomidine
10. ____ the quinines

A. Schistosoma monsoni
B. Plasmodium
C. Leishmania tropica
D. Enchinostomea-Heterophyces-Metagonimus
E. may prove to be useful for Chinese liver fluke now incurable
F. kills Dicrocoelium in sheep, but no cure for man
G. Fasciola hepatica
H. Fasciolopsis buski
I. Bebesiosis
J. Trypanosoma

V. MATCH THE PARASITE TO ITS DESCRIPTION:

1. ____ Fasciolopsis buski
2. ____ Echinostoma ilocanum
3. ____ Heterophyses/Metagominus
4. ____ Opisthorchis sinensis
5. ____ Dicrocoelium dendriticum
6. ____ Fasciola hepatica
7. ____ Schistosoma mansoni
8. ____ Schistosoma japonicum

A. Chinese liver fluke, dogs and cats reservoirs, fish source of human infection.
B. parasite of biliary tree of herbivores from eating ants
C. sheep liver fluke; common problem in France, Algeria, S. A. Caught by eating infected watercress
D. the giant intestinal flike of China, Vietnam and Indonesia
E. Far-eastern lung fluke, crayfish and crab intermediate host, larval stage in snail, adult in man or other mammals
F. minute flukes; Japan, China, Taiwan, Phillipines, Egypt, Israel, Balkans, Spain, U.S.S .R., Indonesia: acquired by ingesting raw or pickled freshwater fish. Fish eating mammals are reservoir.
G. Introduced to U.S. via N. Y. and Puerto Rico, arrived in the Americas via slave trade. Path is snail-rodent-man.
H. medium-sized intestinal fluke; Phillipines, Maloga, Celebes Islands. Rare in man. freshwater snail host.

---

9. ____ Paragonimus westermanni   *I. Chorioretinitis; encephalomyelitis, hydrocephalus*

10. ____ Toxoplasma gondii   *J. Oriental blood fluke; all mammals can be infected; water & moist grassy areas*

EM-16 PARASITOLOGY
PACKET #4 THE CESTODES: END OF PACKET QUIZ

TECHNICAL TERMS:

1. ____ ovicapt	A. male copulatory organ
2. ____ hexacanth	B. muscular sucker
3. ____ cirrus	C. the larva that hatches from the eggs of Eucestoda
4. ____ neoteny	D. filled with eggs
5. ____ fossette	E. a muscular sphincter on the oviduct
6. ____ scolex	F. a ciliated sensory pit
7. ____ velum	G. the occurance of sexual maturity in an otherwise juvenile form
8. ____ acetabulum	H. the holdfast and locomotor organ of a tapeworm; usually anterior
9. ____ vas deferens	I. the overlapping portion of a craspedote proglottid
10. ____ gravid	J. the duct receiving sperm from the vasa efferentia and through which they move toward the cirrus pouch

MATCH THE CREATURE TO ITS BINOMIAL:

1. ____ Diphyllobothrium latum	A. pork tapeworm
2. ____ Taenia solium	B. dwarf tapeworm of house mouse and man; direct life cycle
3. ____ Taenia saginata	C. monzoic, single set of reproductive organs; no scolex
4. ____ Echinococcus granulosus & E. multilocularis	D. broad or fish tapeworm, Scandanavian; our Great Lakes fish
5. ____ Dipylidium caninum	E. beef tapeworm
6. ____ Hymenolepis nana	F. minute dog (Canidae) tapeworm; Hydatid Disease
7. ____ Archigetes	G. cat-dog-chilfren tapeworm. Usually obtained via infected pets; cured with quinacrine
8. ____ Eucestoda	H. matures in coelom of freshwater oligochaetes. (most cestodes mature in vertebrates)
9. ____ Multiceps multiceps	I. polyzoic, one or more sets or reproductive organs per proglottid, scolex present
10. ____ Centodaria	J. a taeniid of dogs and Canidae larvae in herbivores and man: Coenurus Disease

EM-16 PARASITOLOGY
PACKET #5 NEMATODES

MATCH THE NEMATODE TO THE DESCRIPTIVE PHRASE:

1.	____ Ascaris lumbricoides	A. contact with the dog hookworms, Ancylostoma of A. caninum
2.	____ Enterobius vermicularis	B. free-living for some time, rhabditiform, but filariform infective larvae breed in man
3.	____ Ancylostoma duodenale	C. the whipworm, world wide, 3/5 thin esophagus
4.	____ Larva migrans	D. large intestinal roundworm; 20-35 cm. long.
5.	____ Necator americanus	E. the New World hookworm; prevalent now in Africa, South America & North America
6.	____ Strongyloides stercoralis	F. Old World hookworm; only hookworm in Europe & Mediterranean (also now in South America, India, China)
7.	____ Trichuris trichiura	G. African eye worm (but wanders throughout subcutaneous tissues)
8.	____ Loa loa	H. the guinea worm (Fiery serpents which plagues the Israelites)
9.	____ Trichinella spiralis	I. parasite of carnivorous mammals, not host specificity
10.	____ Dracunculus medinensis	J. the pinworm, the most common helminth parasite of the temperate zone

TECHNICAL TERMS: MATCHING

1.	_____ cuticle	A. The esophagus is expanded porteriorly into a bulb which contains a valve mechanism
2.	____ rhabditiform	B. trichinosis
3.	____ Bachman skin test	C. method for recovering Strongyloides using glass funnel
4.	____ paratenic	D. a gurgling abdomen
5.	____ zinc-sulfate method	E. tough protective coating of nematodes
6.	____ Baermann technique	F. to concentrate ova by centrifugation
7.	____ borborygmus	G. loiasis

8. ____ vas diferens	H. hosts which transport the human parasite (e.g. planarians on fresh vegetables)
9. ____ Calabar swellings	I. onchocerciasis
10. ____ Blackfly or buffalo gnat	J. part of male sexual organ

EM-16 PARASITOLOGY
END OF MODULE TEST

I. TRUE-FALSE

1. ____ Most nematodes are parasitic.

2. ____ There are about 10,000 species of nematodes.

3. ____ 'Scabies' in man is 'mange' in animals.

4. ____ Animal inoculation is used to test for trypanosomes; white rats, mice, or guinea pigs will contract the human diseases.

5. ____ The leishmanias are so virulent that most any laboratory animals will contract the disease.

6. ____ Balamuth's aqueous egg yolk infusion is used to culture helminths.

7. ____ The Kato thick-smear technique is used to determine worm burdens.

8. ____ Live dog heart worms are used to prepare the filariasis antigen.

9. ____ Most serological tests for parasites can be done routinely at a local hospital or clinic.

10. ____ Myiasis most commonly occurs in large cities in the colder regions of the world. (e.g. St. Paul, Minnesota; Leningrad; Copenhagen.)

11. ____ Bites of scorpions, centipedes and spiders rarely kill healthy adults.

12. ___ The Spanish fly, Lytta vesicatoria is actually a beetle.

13. ____ The broad fish tapeworm, Fasciolopsis buski, can perforate the bowel an d invade the appendix and other organs.

14. ____ Giemsa stain produces less detail than a blood smear stained with Wright's stain.

15. ____ Intestinal amebiasis is the most readily diagnosed; the symptoms are intense and specific.

16. ____ Entamoeba coli is non-pathogenic.

17. ____ Iodine stains the glycogen in Iodamoeba bütschlii cysts.

18. ____ Sandflies are the natural vector of all leishmaniasis types.

19. ____ Tetrachloroethylene is effective in reducing and controlling echinostome infections.

20. ____ In mixed infections of Ascaris and other intestinal worms, the Ascarsis should be destroyed first.

II MATCHING:

1. ____ Casoni Test
2. ____ Multiceps multiceps
3. ____ Enterobius vermicularis
4. ____ Trichuris trichiura
5. ____ Calablar swellings
6. ____ skin 'snips'
7. ____ Dracunculus
8. ____ chiefly lumen dwellers
9. ____ Schüffner's dots
10. ____ Virchow-Robin spaces

A. the pin worm
B. Loa loa, the African eyeworm
C. fiery serpents which plagued the Israelites
D. Hydatid disease
E. taeniid worm of dogs and other Canidae
F. Onchocerca volvulus
G. Balantidium coli, the ciliate protozoan
H. the whipworm
I. malaria
J. Trypanosoma gambiense

III. ON A SEPARATE SHEET OF PAPER CHOOSE A PROTOZOAN, A TREMATODE, A CESTODE AND A NEMATODE AND DESCRIBE THEIR LIFE CYCLES USING DRAWINGS AND ESSAY.

IV. YOU ARE SENT TO A DEVELOPING NATION IN AFRICA WHERE EDUCATIONAL AND CONSEQUENTLY HEALTH STANDARDS ARE LOW. DESCRIBE WHAT ACTIONS YOU MIGHT TAKE TO LESSEN THE EFFECTS OF PARASITES IN THE POPULATION.

V. YOU ARE SENT TO AN APPALACHIAN TOWN BY THE U.S. PUBLIC HEALTH SERVICE TO SURVEY LOCAL HEALTH STANDARDS. WHAT MIGHT YOU CONSIDER AS PARASITE PROBLEMS?

EM-17 AQUATIC MICROBIOLOGY

__PURPOSE__: To involve the student in the ecology of the aquatic environment.

__MATERIALS__:

1. Laboratory materials of previous modules.

2. Common laboratory equipment for microbiology.

3. How to Know Series - Wm. C. Brown Co. On Algae, Protozoans, Aquatic Plants, Insects, etc.

TEXTS AND REFERENCES

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EM-17 AQUATIC MICROBIOLOGY
MATERIALS: (cont.)

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OBJECTIVES: To enable the student to:

1. Measure limnological parameters.

2. Sample muds, mud-water interface, and the water phases of the aquatic environment.

3. Identify the plants, animals and microbes which live in this environment.

4. Relate the individuals found to one another and to the environment.

NAME: ____________________

EM-17 AQUATIC MICROBIOLOGY

DATE STARTED: ____________

IN THIS UNIT THE TOTAL ECOLOGY OF A FRESHWATER SYSTEM IS STUDIED. AREAS FROM YOUR STUDIES IN BIOLOGY, CHEMISTRY AND MICROBIOLOGY ARE REVIEWED AND ENLARGED SO THAT THE COMPLEX WEB OF LIFE WHICH MAKES UP A STREAM, POND OR ESTUARY BECOMES UNDERSTANDABLE.

PACKET #1:

Utilize the Guide to the Study of Freshwater Ecology edited by William Andres. Read Chapters 1-3 answering the questions on pages 25 & 29. Produce kritter sheets on all new microbes, animals or plants.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ________________

PACKET #2:

Utilize the How to Know the Aquatic Plants key by G. W. Prescott, reading pages vii & viii and pages 1-6. Choose ten (10) references from page 155 for DATA STORAGE and prepare cards. Collect from the environment twenty or more aquatic plants listed in Prescott's keys producing complete F.I.D. sheets and herbarium sheets. For tiny species you may produce microscopic slides and/or liquid preserved samples. Attempt to include species from different families so as to experience most aquatic plant group.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ________________

PACKET #3:

This packet concerns the microscopic examination of specimens from different environments. Follow the direction sheet for Packet #3 and when finished hand in kritter sheets and microscopic slides of all the specimens observed in your fresh water ecosystem. Take self quiz.

DATE COMPLETED: ____________________

INSTRUCTOR SIGNATURE: ________________

PACKET #4:

In this packet you choose the environment that you desire and after doing so follow the direction sheet for Packet #4 and when you have finished what has been instructed hand in kritter sheets and wet mount slides to the instructor.

TAKE THE END OF MODULE TEST. BE SURE YOUR DATA STORAGE AND F.I.D. WORK INCLUDES THE AQUATIC INFORMATION YOU HAVE COVERED.

EM-17 AQUATIC MICROBIOLOGY
PACKET #3 - INSTRUCTION SHEET

THE DISTRIBUTION OF MICROORGANISMS IN THE AQUATIC ENVIRONMENT .

Environmental microbiologists know that microorganisms thrive in a wide variety of natural environments They are ubiquitous on land and water and have been found at altitudes of up to 40,000 feet! Microbial populations are composed mostly of bacteria, fungi and protozoa.

Many factors play decisive roles in establishing the population of a particular region. In water, the numbers and kinds of microorganisms present are determined by the physical and chemical properties of the water, the presence of plants and the degree of contamination of plants and animals. These conditions control the numbers and kinds of microorganisms present. Microbial ecology is the term used to denote the study of microbes and their relationships with the environment and each other.

THIS PACKET CONCERNS THE MICROSCOPIC EXAMINATION OF SPECIMENS FROM DIFFERENT ENVIRONMENTS.

MATERIALS PROVIDED:

1. Beaker containing fresh water ecosystem.
2. Nutrient agar plate.
3. Sterile cotton-tipped applicator sticks.
4. Glass slides and cover slips.
5. Pasteur pipettes.
6. Utilization keys to fresh-water algae, protozoans, fungi and notes on bacteria to identify fresh water ecosystmes major components.

INSTRUCTIONS:

1. Prepare wet mount of each specimen provided.
2. Examine each preparation with the low-power and high-power objectives.
3. Try to identify microorganisms present.
4. Answer questions at the end of this exercise. (Self-correcting quiz.)

EM-17 AQUATIC MICROBIOLOGY
PACKET #3 - SELF-CORRECTING QUIZ

NAME: ____________________
DATE: ____________________

THE DISTRIBUTION OF MICROORGANISMS IN THE ENVIRONMENT.

1. Were the major types of organisms encountered in the pond water and environmental specimen different? Explain.

2. What factors would account for a lack of good growth on your nutrient agar plate?

3. Would viruses and rickettsia normally be found in either pond water ecosystems or on your nutrient agar plates? Why?

4. DEFINITIONS:

DIATOM
SLIME MOLD
PROTISTA
RICKETTSIA
SYMBIOSIS
MUTUALISM
COMMENSALISM

USE BACK OF THIS SHEET FOR DEFINITIONS.

EM-17 AQUATIC MICROBIOLOGY
PACKET #4

INSTRUCTIONS: ISOLATES FROM THE ENVIRONMENT THAT YOU HAVE CHOSEN.

---

1. Secure specimen using the sterile applicator sticks from any environment that you have chosen.

2. Streak the nutrient agar plate by running the cotton-tipped applicator stick over the surface of the agar in a zig-zag pattern.

3. Mark bottom of petri dish with location where specimen was obtained.

4. Check this plate at one, two, three, five and seven days recording the ecological changes noted.

5. Produce wet mounts of the isolates that you deem necessary.

EM-17 AQUATIC MICROBIOLOGY
END OF MODULE TEST

I. TECHNICAL TERMS: MATCHING

1. ____ niche

2. ____ herbivores

3. ____ carnivores

4. ____ phytoplankton

5. ____ epilimnion

6. ____ littoral zone

7. ____ hypolimnion

8. ____eutrophic

9. ____ metalimnion

10. ____ oligotrophic

A. the upper, warmer, freely-circulating stratum of water in a pond.

B. a lake with high productivity and fertility (Possibly from man-made pollution).

C. the lowest and coldest stable bottom water

D. a clear, low productivity, low fertility lake

E. animals which feed directly upon green plants

F. the main producers of an aquatic ecosystem

G. a transition layer of water from warmer to colder water (1°C/1 meter depth change); the thermocline

H. an ecological role

I. that region where rooted plants will grow and light penetrates to the bottom

J. animals (or plants) which feed directly upon other animals

II. What role do the following elements play in the life processes of plants and animals.

CARBON.......

HYDROGEN ....

OXYGEN ......

NITROGEN.....

PHOSPHORUS...

SULFUR.......

CALCIUM......

MAGNESIUM....

BORON........

MOLYBDENUM...

III. You were asked in this module to consider the Venus Fly Trap, the skunk and man and to show what niche they belong to and to show their places in an ecosystem. Do so again here and discuss the question..... Is there any ecosystem of which man is not a part?

IV. What factors influence a lake or marine pH?

V. KNOWING AQUATIC ANIMALS: MATCHING

1. ____ *Gerris* sp.
2. ____ *Gyrinus* sp.
3. ____ *Tokophrya* sp.
4. ____ *Hydra* sp.
5. ____ *Tubifex* sp.
6. ____ *Asellus* sp.
7. ____ amphipods
8. ____ *Daphnia* sp.
9. ____ *Cyclops* sp.
10. ____ *Lethocerus* sp.

A. the sludgeworm, a segmented advanced worm

B. a cladoceran or water flea

C. the water stridder pond skater or wherryman

D. a typical Suctoria, a predatious protozoan which feeds on other protozoans

E. an isopod; an aquatic 'sow bug'

F. the scuds or sideswimmers

G. the whirligig beetle; one half each eye looks up or down

H. the giant water bug

I. have five or six long tentacles, are close to microscopic and are carnivorous; it poisons its prey

J. a common copepod

IV. KNOWING AQUATIC MICROBES: DRAW THE GENERALIZED MORPHOLOGY OF THE FOLLOWING:

TABELLARIA

COSMARIUM

VOLVOX

ANABAENA

CLOSTERIUM

NAVICULA

CHLAMYDOMONAS

OSCILLATORIA

RIVULARIA

TETRAPEDIA

VII. KNOWING AQUATIC PLANTS: MATCHING

1. ____ Chara
2. ____ Elodea
3. ____ Cabomba
4. ____ Utricularia
5. ____ Ceratophyllum
6. ____ Myriophyllum
7. ____ Chiloscyphus
8. ____ Salvinia
9. ____ Trapa
10. ____ Potamogeton

A. the bladderwort
B. coontail or hornwort
C. water fern
D. muskgrass or stonewort
E. cold water, running liverwort
F. the fanwort
G. the common water weed
H. water chestnut
I. pondweed
J. water milfoil

VIII. AQUATIC PLANT CLASSIFICATION: COMPLETE THE TABLE AS THE EXAMPLE SHOWN. USE ONLY AQUATIC PLANTS.

PHYLA OR CLASS	COMMON NAME	FAMILY	GENUS
Spermatophyta (Angiospermae)	Waterweed:Anacharis	Hydrocharitaceae	Elodea
Chlorophyta			
Euglenophyta			
Chrysophyta			
Cryptophyta			
Pyrrhophyta			
Cyanophyta			
Phaeophyta			
Rhodophyta			
Chloromonadophyta			
Bryophyta (Hepaticae)			
Bryophyta (Musci)			
Psilopsida			
Lycopsida			
Sphenopsida			
Pteropsida			
Spermatophyta (Gymnospermae)			
Fungi			
Actinomycete			
Bacteria			

YOU MAY USE YOUR KRITTER NOTEBOOK

IX. What special procedures are required for collecting aquatic plant and animal specimens? This requires a brief essay and/or listing of steps necessary.

EM-18 SOIL MICROBIOLOGY

PURPOSE: To introduce the forester, horticulturalist, ecologist or naturalist to that world of plants, animals and microbes which live beneath the surface of the earth, both terrestrial and marine.

MATERIALS:

1. Contact Slide Technique Sheet
2. Spore-forming Bacteria Kit
3. Fungus Collecting Kit
4. Soil Microfauna Kit

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EM-18 SOIL MICROBIOLOGY
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OBJECTIVES: To enable the student to:

1. Collect and/or capture soil algae, protozoans, bacteria, actinomycetes, fungi, nematodes and macrofauna.

2. Classify collected organisms.

3. Study soil life IN SITU.

4. Produce stained slides and other apecimens for long term storage of organisms.

5. Maintain soil organisms in artificial media.

DATE STARTED: ____________________

EM-18 SOIL MICROBIOLOGY INSTRUCTION AND CHECK OFF SHEET

This individualized module is prepared for the forester, horticulturalist, or ecologist who wishes to understand the living world beneath our feet. This module should be of importance to workers in water and wastewater, soil conservation, land planning and forest nursery. Sections of this module are required in several NRM courses.

PACKET #1 - If not already versed in basic biology, soils and ecology review Chapters 1 and 2 in Andrew's SOIL ECOLOGY. Read Chapters 3 and 4 for detail. Prepare answers to the questions at the end of the chapters - pgs. 80, 95 and 96. Hand into instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2 - Read the following pages in Parkinson, Gray and Williams: ECOLOGY OF SOIL MICROORGANISMS: 1. Objectives; 2. Habitat Description; 3. Sampling (6-9, 15-18).* Those students who have taken statistics may complete pages 10-14; 4. Form and arrangement (19-21, 28-35): 5. Isolation of Soil Organisms: Prepare Data Storage Cards for pages 102-104. The sections not mentioned in this packet are important in more detailed soil studies. Do make up DATA STORAGE CARDS for IBP Handbook No. 19 and other handbooks on the back cover. TAKE SELF-QUIZ.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3 - Read the packet of reproduced articles from soil literature included in this module. MAKE UP DATA STORAGE CARDS. You may use the Data Storage Cards to take the end of module test. These articles will vary from time to time to fit student needs and interests.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4 - MICROBES BY DIRECT CONTACT TECHNIQUE.
Show four (4) drawings of different locations on the slide. Identify microbes to major groups. Estimate numbers. Show slide and kritter sheets to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #5 - From a sample of soil collect and count the spore forming bacteria. Show your plates, slant and kritter sheets to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

EM-18 SOIL MICROBIOLOGY
INSTRUCTION AND CHECK OFF SHEET (cont.)

PACKET #6 - From sample of soil collect and identify at least one fungus. Use the keys available in the laboratory. You may ask for help. Show plates, slant and slides and kritter sheets to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

PACKET #7 - Read Schaller's SOIL ANIMALS. Utilize the soil macrofauna kit or techniques from Schaller on soil animals to isolate arthropods insects, nematodes and other semi-microscopic organisms. Count and identify. Show kritter sheets, slides and preserved specimens to instructor. You may conduct your own experiment in this packet.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

TAKE END OF MODULE TEST.

DATE COMPLETED: ______________________
TEST: ________________________________
KRITTER SHEETS: ______________________
DATA STORAGE CARDS: __________________
INSTRUCTOR SIGNATURE: ________________

EM-18 SOIL MICROBIOLOGY
PACKET #2 SELF-QUIZ

---

1. What areas of study are particularly difficult in soil microbiology?

A. B.

2. What group of bacteria are not covered by this handbook?

3. What are the three basic site units needed to study terrestrial microbial ecology?

A.

B.

C.

4. What are the soil factors to be considered during microbial study?

A. B.

C. D.

E. F.

G.

5. What are the above ground biotic factors which should be measured when studying soil microbiology?

A.

B.

C.

6. What are the below ground factors?

A.

B.

C.

7. There are two reasons for which a soil sample may be taken. They are:

A.

B.

---

8. The method of Clarke (1965) is used when ______________________________

9. The essentials in the method are:

   A.

   B.

   C.

   D.

9. The methods of Stotzky et. al. (1965) is used when: ____________________

10. To get a good statistical sample the investigator must be aware of:

    A.

    B.

    C.

11. In planning a sampling technique what should be included?

    A.

    B,

    C.

    D.

12. What are the seven growth patterns which microbes might display in soil studies?

    A.

    B.

    C.

    D.

    E.

    F.

    G.

---

13. How did Kubiena (1938) observe soil microbes?

14. How did Burges and Nicholas (1961) observe soil microbes?

---

1. What three basic site units are used in ecological studies. Be brief; use space provided.

A.

B.

C.

2. Name five soil factors which may require monitoring during ecological studies.

A. B.

C. D.

E.

3. Name five biotic factors which may require monitoring during ecological studies.

A. B.

C. D.

E.

4. What meteorological factors may require consideration in soil studies. Name five.

A. B.

C. D.

E.

EM-18 SOIL MICROBIOLOGY
PACKET #2 SELF-QUIZ (cont.)

TRUE-FALSE

1. ____ Polyethylene containers should be avoided because they lose water vapor. (Page 7)

2. ____ Since soil is very variable measurement error often exceeds sampling and selection error. (Page 8)

3. ____ At least two and preferably more samples must be drawn from the same soil unit and evaluated separately to allow any assessment of variability to be made. (Page 15)

4. ____ The sampling unit which is to be studied should be as heterogeneous as possible. (Page 15)

5. ____ Capillary techniques do not improve upon buried slides since they become clogged easily. (Page 33)

6. ____ The Fahraeus slide technique is used to study microbe-plant root relationships such as microrhiza. (Pg. 34.)

7. ____ Direct isolation of fungal hyphae by the Warcup method assures that only the fungi survive and that all fungi are trapped. (Page 38)

8. ____ Bacterial cells are too small to be removed directly from soil. (Page 38)

9. ____ Antagonistic microbes are not often found in random isolates. (page 42)

10. ____Washing techniques are used only if it is desired to separate constituent particles from soil prior to isolation microbes. (Page 43)

11. ____ Serial washings are accomplished using sieves graded by size. (Page 44)

12. ____ Colloidal substances cause no problem in soil sieve washing since several washings will suffice to remove clinging propagules. (Page 45)

13. ____ Actinomycetes are best detected and isolated using one of the fragmentation techniques. (Page 47)

14. ____ Maceration techniques are used to study internal parasites of roots. (Page 48)

15. ____ A good binocular microscope and a micro-manipulator are required for root dissection microbe isolation. (Page 49)

16. ____ Actinomycete spores are more easily destroyed by abrasion than their pseudomycelia. (Page 49)

17. ____ Spore-forming bacteria are isolated by killing all others with a temperature of 80°C. (Page 50)

18. ____ Drying a soil kills fungi and actinomycetes, but leaves most bacteria viable. (page 51)

19. ____ Winogradsky invented the soil block technique. (Page 52)

20. ____ Humidity may be controlled in a humidity chamber by using appropriate salt solutions. (Page 56)

MATCHING: TECHNICAL TERMS

1. ____ unicellular, restricted, non-motile
2. ____ restricted mycelial pattern
3. ____ mycelial strands
4. ____ plasmodial pattern
5. ____ fluorescent anti-sera technique
6. ____ scanning electron microscopy
7. ____ transmission electron microscopy
8. ____ buried slide technique
9. ____ impressions of laboratory soils
10. ____ pedoscopic methods

A. the mxyomycetes and mxyobacteria; aggregation and swarming

B. requires production of diamond sawn thin-sections

C. bacterial colonies; yeast cells

D. Lingappa-Lockwood

E. a rhizomorph pattern such as many basidiomycetes

F. Rossi, Riccardo, Gesue, stanganella, Wang, Tribe, Gray, Bell, Lowe

G. Perfiliev-Gabe use capillary

H. Penicillium, Streptomyces: fungi which do not extend hyphae beyond colony

I. examine microbes on the surface of soil particles

J. the only method by which organisms may be identified in soil directly without isolation and diagnosis. (e.g.: Rossi-Cholodny slides)

MICROBES BY DIRECT CONTACT TECHNIQUE:

Direct methods of observing microorganisms in soil include microscopic examination of thin sections of undisturbed samples of soil, examination of smears of soil suspensions, and observation or isolation of organisms growing on glass slides injected into soil in situ. The direct method often gives an estimate of the number of cells without cultivation of the organisms, thus avoiding the complicating factors of selection of media and environmental conditions necessary for growth in vitro.

Some advantages of the direct methods are:

1. *All cells can be counted.*
2. *Morphology can be seen.*
3. *Dimensions can be measured.*
4. *Spatial relationships between cells and other soil particles as they exist in the natural environment can be seen.*

The disadvantages are as follows:

1. *Living and dead cells are hard to tell apart.*
2. *Similar organisms are difficult to identify further.*
3. *Filamentous organisms can be hard to count.*
4. *Representative soil samples can be difficult to obtain because very small amounts of soil can be used.*

Isolation of organisms by direct methods is a challenging procedure, but isolation is required if further studies are to be made on the morphology and physiology of the observed organism. Most so-called direct isolation procedures employ a synthetic agar medium for proliferation of the organism. Single-cell isolations by microscopic techniques are not often used, probably because of the inherent difficulties in conducting the necessary operations in a medium where the mass of inert particles is so much greater than that of living particles; but this technique offers promise, especially in combination of other techniques.

CONTACT SLIDE TECHNIQUE:

The original contact-slide technique involves observation of organisms adhering to a microscopic slide that has been left for a time in contact with soil. The technique was proposed by Cholodny (1930) and Rossi et. al. (1936) as a way of observing some of the characteristics of the soil population in relation to the environment. Accurate measurement of numbers of cells in soil can not be made. Isolation of tje organisms ovserved is difficult. Some organisms are more attracted to surfaces than others. Modifications include an impression-slide technique (Brown, 1958) to study a thin sample of the soil surface by coating the slide with adhesive to hold the soil particles. Cellulose decomposition was studied (Tribe, 1957) by placing a cellulose film on the face of the slide. Other materials, such as nylon and grass cloth, have been used for burial, Isolation directly from soil is more commonly done by one of the trapping methods *done by using agar media, as described by Johnson et. al. (1959). Recently the Russians have developed capillary methods of great promise.*

The objective of the contact-slide technique is to observe the soil population in its natural state. Transfer of the organisms to a glass slide facilitates the observation because it eliminates most of the interference dur to other soil particles. Pushing a glass slide against a fresh soil surface or crushing soil crumbs against the slide reveals only those organisms present at the time of sampling that will stick to the glass when dried. If the slide is buried for a time in the soil, both the organisms that stick to the glass and the organisms that develop on it can be observed. If careful technique is used, sporulating bodies remain intact; observations may be made of colony characteristics, feeding or organisms on materials, and response of organisms to environmental factors, such as water films. Use of the phase microscope will make possible live observations.

METHOD:

FOR THIS EXPERIMENT YOU WILL NEED:

1. *Clean glass slides - thoroughly wash and flame just before use to ensure sterility.*
2. *Phenolic rose bengal: Dissolve 1.0 g rose bengal and 0.01 g of* $CaCl_2 \cdot 2\,H_2O$ *in 100 ml of 5% aqueous phenol (if not already prepared).*

PROCEDURE:

1. *Insert glass slide (sterile) vertically into soil sample leaving ½" above surface. Press soil gently against slide.*
2. *Incubate for 1-3 weeks.*
3. *Then, remove slide carefully, by breaking the slide away from the undisturbed side by moving the slide parallel to the soil surface.*
4. *Remove large clumps of soil and air-dry slide.*
5. *With a small stream of water remove soil on undisturbed side until only a small film remains.*
6. *Clean disturbed side with a damp cloth until all soil is removed.*
7. *Fix the slide by air drying and heating over a low flame.*
8. *Now, place slide over boiling water bath and flood it for 6 to 10 minutes.with phenolic rose bengal by dropping rose bengal solution on slide as it drys.*
9. *After 6 - 10 minutes wash slide gently with water to remove excess stain.*
10. *Air dry slide.*
11. *Examine slide microscopically.*
    - *A. 10X and 43X to view fungi, plant rootlets, encysted nematodes and other larger microbes.*
    - *B. Use oil immersion to examine bacteria.*

EM-18 SOIL MICROBIOLOGY
PACKET #5 AEROBIC SPORE FORMERS

To supplement the total microbial count of soil, one might desire to determine the occurrence of specific organisms. This commonly involves the determination of microbes present in soil in such low numbers that they cannot be expected to appear in the range of inoculant dilution employed for total counts. Simply plating the soil sample at a lower dilution produces so many colonies that the growth of the organism of interest cannot be recognized. By the method of selective culture or elective culture it is possible to grow colonies of a certain species that you are looking for in a soil by creating conditions favorable for growth of that species and unfavorable for others. It is then possible to determine the occurrence and frequency in soil of particular groups, genera, or even species.

In many soils, the aerobic spore-forming bacteria comprise about 10% of the bacterial count.

SELECTIVE CULTURE

This is achieved by making the media such that only the organism of interest can grow. It makes no difference how many other creatures are in the inoculant since conditions will be such that only the chosen organism can survive. This is done by selecting that nutrient that encourages the growth of the organisms. When a certain nutrient encourages growth of more than one organism you can use antibiotics, dyes, enzyme inhibitors, and varying degrees of acidity to obtain a media which is selective.

Another method is to make the inoculating material selective or the incubation such that it will kill off the other organisms.

To create selective culture of aerobic, spore-forming bacteria the method used is pasteurization, which is the partial sterilization by heat, of a dilute soil suspension to eliminate the non-spore-forming bacteria from the inoculant before pouring into petri dishes. The objective of this heating is to kill the nonsporing bacteria but to keep as many viable spores of *Bacillus* as possible. Heat treatment at a temperature of about $80^{o}C$ suffices to kill most nonsporing bacteria. The pasteurization process does kill all of the nonsporing cells of *Bacillus*, so that the count obtained is the number of spores and is not that of cells.

Since only the Bacillus spores survive the heat treatment, the question may be raised as to how meaningful is the spore count in relation to the total number (vegetative and spore cells) of *Bacillus* in soil. Some say that the resting spore population represents only an inert population or an active population that existed in the past, and that a spore count fails to reveal any current and intense activity of vegetative cells. It is well to keep in mind that cell counts, even of vegetative cells, are not reliable indexes of physiological activity. It is also true that periods of profuse vegetative growth of *Bacillus* are commonly accompanied or followed by heavy sporulation.

MATERIALS NEEDED

1. Nutrient Agar: Prepared. Sterilize at 15 lbs. psi for 15 minutes.
2. Water blanks: Using the 100 ml. bottles provided prepare one bottle with about a dozen glass beads and 95 ml of distilled deionized (d.d.) water. Prepare 7 other bottles with 90 ml. of d.d. water and no beads. These may be prepared well ahead of time and stored. STEAM STERILIZE.
3. Soil Extract: This is perpared to provide a normal trace element background for future agar solutions.
    - a. Mix 1 kg of local fertile soil with 1.5 liters of tap water.
    - b. Autoclave at 15 psi for 15 minutes.
    - c. After partial cooling and settling, filter the suspension using a Büchner funnel and filter aid.
    - d. If solution is not clear let stand in refrigerator at 40°C overnight and decant into a sterile container.
    - e. Store close to freezing point until used.

4. Dilution Series:
    - a. Transfer 10 grams of moist soil to a sterile glass-beaded water blank using waxed paper and brush. Cap.
    - b. Shake vigorously for 15 minutes.
    - c. Remove 10 ml using sterile pipette.
    - d. Transfer to unbeaded water blank. This establishes a 10^{-2} dilution.
    - e. Transfer to another unbeaded water blank 10 ml from the 10^{-2} dilution, making a 10^{-3} dilution.
    - f. From the 10^{-3} continue the process as above until the dilution of 10^{-7} is reached.

METHOD

From each water blank containing dilutions of 10^{-3} to 10^{-7} transfer 25 ml of the freshly agitated suspension to a sterile flask. Immerse the five flasks containing dilutions of 10^{-3} to 10^{-7} in a water bath at temperatures 80-85°C. Be sure that you mark flasks as to which dilution is in which flask. Keep flasks in water bath for ten minutes and during this ten minute period shake or rotate several times. The water level in the water bath should be higher than the level of water in the flasks. From the dilutions transfer 1 ml by sterile pipette to petri dishes and add melted nutrient agar which is cooled to 42°C. Rotate the dishes to ensure thorough mixing of agar and inoculum. After all plates are poured and swirled, shut covers and incubate at 30°C for 4 days. After four days omit colonies showing more than 300 but less than 30. During incubation plates should be inverted.

INDICATE COUNT AS FOLLOWS:

DILUTION	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
Plate 1					
Plate 2					
Plate 3					

As one can see by the chart, all dilutions are done in triplicate on the petri dishes.

EM-18 SOIL MICROBIOLOGY
END OF MODULE TEST

MATCHING:

1.	____ enchytraeid	A. winged insects
2.	____ isopods	B. smaller, white, relative of the earthworm an oligochaete; potworm
3.	____ Pedipalpi	C. whip scorpions
4.	____ Collembola	D. larva of the click beetle
5.	____ wireworm	E. the Bear animalcule
6.	____ Tardigrade	F. pill bugs and other wood louse forms
7.	____ Turbellaria	G. snake millipedes; vegetarians
8.	____ Julids	H. flat worms
9.	____ Chilopads	I. centipedes
10.	____ Pterygota	J. the true springtails

TECHNICAL TERMS: MATCHING

1.	____ pseudostigmatic organ	A. Chernozem
2.	____ clitellum	B. tactile hair
3.	____ invaginations	C. preoral appendages which produce 'spittle' threads (Scytodes thoracica)
4.	____ red rot	D. tactile body hairs
5.	____ black earth	E. occurs in moist sites where anaerobic bacteria and nematodes abound
6.	____ orbatid	F. beetle mite
7.	____ rendzina	G. primary soil on firm substrate
8.	____ trichobothria	H. A-horizon on heavy red clay
9.	____ chelicerae	I. the glandular collar of earthrowms; secretes mucous envelope to allow copulation
10.	____ laterite	J. the lunglike infoldings which serve as gills on the abdomenal appendages of wood lice.

MAJOR SOIL ECOLOGISTS MATCHING

1. ____ Darwin	A. sexual behavior of Symphyla
2. ____ Stockli; Bellinchen; Kuhnelt	B. fungus classification
3. ____ Dunger-Stockli-van der Drift	C. hanging soils and epiphytic soils of tropical jungles
4. ____ Jean Henri Fabre	D. direct observation of microbes on immersion slides
5. ____ H. Sturm	E. made of the first quantitative estimates of earthworm densities (in pasture soils)
6. ____ Mme. L. Juberthic-Jupean	F. rhizosphere microbiology
7. ____ Delamore-Deboutteville	G. soil ecology computational methods
8. ____ Rossi-Cholodny	H. explained the 'promenade a deux' of Scorpions - indirect spermatophore transfer
9. ____ Krasilnikov	I. recent earthworm counts: clayey soils of Switzerland; heaths and pastureland
10. ____ Ainsworth-Bisby-Clements-Shear	J. whip scorpion by button-cheliccrae spermatophore transfer; also love play of the machilids.

ON SEPARATE KRITTER SHEETS EXPLAIN HOW YOU CAPTURE, COUNT AND MAINTAIN, STORE OR FIX:

A. BACTERIA

B. ACTINOMYCETES

C. PROTOZOANS (AMOEBA, FLAGELLATES, CILIATES)

D. NEMATODES

E. FUNGI AND SLIME MOLDS

F. METAZOANS (WORMS, TANDIGRADES, MOLLUSKS, ARTHROPODS, INSECTS)

G. VERTEBRATE ANIMALS (AMPHIBIANS, REPTILES, MAMMALS)

EM-19 PROTOZOANS

PURPOSE: To introduce to the environmentalist the diverse group of protists known as protozoans; to familiarize the researcher with the major members of this class: Mastigophora, Sarcodina, Ciliophora, Sporozoa and Coccidia.

MATERIALS:

1. **Protozoan Kit:** Hanging drop depression slides; methyl cellulose, stains, protozoan rings, nutrient agar and common microbiological equipment.

2. Jahn's How to Know the Protozoa - Wm. C. Brown Company, Dubuque, Iowa.

3. Handout - Protozoan Classification

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EM-19 PROTOZOANS (cont.)

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OBJECTIVES: To enable the student to:

1. Capture, isolate and identify protozoans.
2. Maintain stock cultures of protozoans.
3. Understand the ecology of protozoans.
4. Produce slides for both live and stained protozoans.

DATE STARTED: ______________________

EM-19 THE PROTOZOANS INSTRUCTION AND CHECK OFF SHEET

The simplest animals are the first animals, the "proto" animals. They have lived and evolved for millenia and now comprise a diverse group which often defies the taxonomist. Some are more like bacteria or fungi than animals. Some are plant-like. Some are dangerous to man or his crops or animals. Some are useful as bacteria "foragers". They are very interesting to the resource manager. In this module you will study the biology of protozoans, their classification, their mode of capture, their identification, and some factors concerning protozoan ecology.

PACKET #; - Read the preface and Chapter 1 of Sleigh's THE BIOLOGY OF PROTOZOA. Utilize the prepared slides which accompany this module producing kritter sheets on each species viewed. Utilize the programmed review and then take self-correcting quiz.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #2 - LEARNING HOW TO IDENTIFY PROTOZOANS.
Read Chapter 2 in Sleigh's THE BIOLOGY OF PROTOZOA and pages 1-51, 99-101, 142-143 and 168-169 in Jahn's HOW TO KNOW THE PROTOZOA. Utilize the Protozoan classification chart to note how different biologists class these troublesome creatures. Complete the programmed review and then request the self-correcting quiz.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #3 - PROTOZOAN COLLECTION AND ENUMERATION
Utilize the live material available to produce hanging drop slides of protozoans. Call the instructor's attention when the protozoan is in view and slowed with methyl cellulose. Submit stained slides of those protozoans studied. Utilize the accompanying methods sheet to capture a protozoan from a field sample. Work up a kritter sheet for identification.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #4 - Utilize Sleigh's book and prepare a 5-10 page report on one of the following groups: FLAGELLATES, OPALINIDS, AMOEBOIDS, CILIATES, SPOROZOA OR CNIDOSPORA. Other references are available including A. R. Jone's THE CILIATES. The report will be typewritten.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #5 - Read Singh's articles on "Selectivity of Bacterial Food by Soil Amoebae". Utilize programmed review.

DATE COMPLETED: ______________________
INSTRUCTOR SIGNATURE: ________________

PACKET #6 - Read Singh's "A Method of Estimating the Numbers of Soil Protozoa....". Prepare technique sheet for F.I.D. Notebook. Sumbit sheet to instructor.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

TAKE END OF MODULE TEST: *DATE COMPLETED:* ____________________

PROTOZOAN CLASSIFICATIONS

	According to: Ford & Munroe Living Systems	According to: Jahn The Protozoa	According to: Sleigh The Biology of Protozoa
KINGDOM	PROTISTA	ANIMAL	ANIMAL
PHYLA	Mastigophora	Protozoa	Protozoa
	Sarcodin		
	Sporozoa		
	Ciliophora		
SUBPHYLA	-none-	Mastigophora	Sarcomastigophora
		Sarcodina	
		Sporozoa	Sporozoa
		Ciliophora	Ciliophora
			Cnidospora

1. Note that many modern taxonomists divide all life into more than just animal and plant kingdoms. Many add Moneran and Protista kingdoms and call the Animal Kingdom Metazoa; the Plant Kingdom, Metaphyta.

2. Note also that many taxonomists raise creatures from subphyla 1 level (or below) to Phylum level. e.g.: In the text Living Systems the four subphyla of Protozoa are raised to Phylum level.

3. Note finally that Sleigh has divided the Protozoa into four different subphyla. He groups Mastigophora and Sarcodina into one group, the Sarcomastigophora. He adds a group, the Cnidospora which others often call metazoan. Ford and Munroe place these creatures under Sporozoa as Cnidosporidea.

As is true throughout our studies we shall use the system utilized by the field keys, the Jahn system. Be aware that the study of Protozoa is active and subject to change.

EM-19 PROTOZOANS
PACKET #1 PROGRAMMED REVIEW

1. What authors mentioned by Sleigh should be in the DATA STORAGE file?	
2. What are the major Journals of protozoology? (List in F.I.D. NOTEBOOK and make up DATA STORAGE CARDS.)	1. From Sleigh's bibliography Grasse - 90 Grell-92 Mackinnon & Hawes-165 Sandon-222 Dogiel-67 Kudo-145 Pitkelka-198 Baker-9 Vickerman & Cox-274
3. According to Sleigh the protozoa are comprised of four groups: the ________________, ________________, and ___________________ which are entirely animal and the ___________________ which contains both plant and animal. To Sleigh these are taxonomically ______________________________.	2. Research in Protozoology Protozoa in Biological Research Biochem & Physiol. of Protozoa Acta Protozoologia Hydrobiologia Protistologica (Fr.) J. of Protozoology
4. The plantlike flagellates are classed as ____________________, and those definitely more animal-like are classed as ____________________. Many of the Phytamastigophorea will be encountered in the Algae Module because algologists and many other botanists class all chlorophyll containing unicellular life as algal.	3. Ciliophora Sporozoa Cnidospora Sarcomestigophora sub-phyla
5. One common flagellate Chrysophyte protozoan is ____________________. Like many flagellates they have two flagella of unequal ______________. Other flagellates usually have 2, 3 or 4 flagella.	4. Phytamastigophoran Zoomastigophorea
	5. Ochromonas length This creature should be added to F.I.D. notebook. Consult, however, FRESHWATER ALGAE - pgs. 206. 230 and PROTOZOA pg. 54.

6. The most well known Sarcodina is A____________ proteus. There are basically only two phases to the cytoplasm, the superficial ________________ and the internal _________________. It is also called ______________ ________________.

7. Another restricted group is the opalinid Protozoa which have _____________ like Ciliates but reproduce like ________________. The specialized parasitic Protozoa are classed as _____________. Only recently have they been grouped as closely related because their sexual cycle reveals they are ________________ organisms with a zygotic meiosis. Their gametes do possess ______________.	6. Amoeba ectoplasm endoplasm Chaos diffluens This creature is shown on pg. 120 in Jahn and on pgs. 3, 4, 21-23, 25, 46, 69, 76, 156-164, 266 and 287 in Sleigh. IT DESERVES A KRITTER SHEET.
8. Members of the ______________ have distinctive spores whose infective __________ are ___________. Sporozoa have regular shaped spores called _________. Draw these contrasting spores (important in their identification.)	7. cilia flagellates Sporozoa haploid flagella
9. Most clearly different from other living organisms and other protozoans are the ciliates or _______________. Their pellicular organization is unique having cilia; they show nuclear __________ and sexually practice ________________. Ciliates are diploid with gametic meiosis, just like people opalinids, heliozoans, and some ______________ are also diploid.	8. Cnidospora contents amoeboid sporozoites SPORE TYPES BELONG ON KRITTER SHEET
10. The body surface of ciliates is covered with rows of cilia called ___________. Their mouth is in a depression the _____________ cavity which leads to the ________________. The infraciliature and other 'skin' organelles make up the __________. The inner cytoplasm is more fluid.	9. Ciliophora dimorphism (two separate forms) conjugation zooflagellates
	10. kinetics buccal cytostome pellicle

EM-19 PROTOZOANS
PACKET #1 END OF PACKET QUIZ

---

1. List three major scientists doing contemporary work on protozoology.

   A.

   B.

   C.

2. List three major journals which could be consulted when working with protozoans. GIVE COMPLETE DATA STORAGE INFORMATION.

   A.

   B.

   C.

3. What characteristics of some protozoans makes them difficult to classify in the more classical schemes for taxonomy.

4. Describe typical Sporozoa.......USE DRAWINGS.

5. Describe typical Cnidospore.....USE DRAWINGS.

6. Describe typical Chrysophyte......USE DRAWINGS.

7. Describe typical Amoeboid (Sarcodina).....USE DRAWINGS.

8. Diagram Tetrahymena and show how it is classified.

USE SEPARATE KRITTER SHEETS FOR QUESTION 4-8 and hand into instructor for credit.

9. Discuss the ancestral origin of the metazoans in relationship to the development of protozoans and green algae.

10. Compare and contrast procaryotic v.s. eucaryotic organisms.

EM-19 PROTOZOANS
PACKET #2 THE PROTOZOA: T.L. JAHN

USE THIS PROGRAMMED REVIEW TO DETERMINE HOW WELL YOU UNDERSTAND HOW TO KNOW THE PTOTOZOA.

---

1. Courses in Protozoology are generally taught at large Universities to _________________ students or advanced _________________. This book might be useful to them, but is designed for ________________ advanced students.	
2. The Protozoa are often called"simple" "_________" animals. There are some 15-20 ____________ species. Jahn emphasizes that they ARE NOT SIMPLE nor are they all unicellular; they may not in every case be ANIMALS.	1. graduate undergraduate less
3. Consider the shelled amoeba, Arcella disc oides. Just as we contract muscles it contracts its ______________. It operates, as our muscles do, by causing long _____________molecules to ____________ upon themselves to cause shortening. Put A. discoides in your Field Identification Notebook.	2. unicellular thousand
4. The excretion of _______________ through the ___________ vacuole of Paramecium sp. (note pages 186-192 and produce sheets for major species) is not very different from excretion from a ______________ kidney. Many of the organisms we call protozoa have more than one ______________. Paramecium has one _______________ and one or more ____________________.	3. pseudopodium protein fold
5. Arcella has ___________ nuclei. Insect intestinal protozoa often have _______________ nuclei. The giant free living amoeba _____________________ has several nuclei. Place the GIANT in your notes.	4. liquids (fluids) contractile mammalian nucleus macronucleus micronuclei
	5. two equal several Chaos carolinensis hundred

6. Not only do protozoans often have more than one nucleus, but their ______________ is not divided into compartments. In ________________ the giant, and in _________________ a ciliate that lives in frogs there are many ______________ which are not divided into _________________. These protozoans which live in colonies usually have only a single _________________, and they have cell _____________. They ___________ classed as Metazoa, because when the colonies break apart they can still carry on most ________________.

---

7. In the formation of the spore of creatures like *Myxobolus okobojiensis*, one of the class ____________, there is ______________ number of cells to form the ___________________ capsules and __________________ membranes. Sleigh in The Biology of Protozoa discusses the suggestions that these creatures be placed in a separate Phylum. He concludes that despite the Metazoan stages in the life of Cnidospora that they are _____________________.

6. protoplasm
Chaos carolinensis
Opalina sp.
nuclei
compartments
nucleus
walls or membranes
are not
body functions

---

8. Many of the chlorophyll bearing ___________ are very closely related. *Cryptomonas* has _______________, but _____________ which looks like it does not. *Euglena* looks like ______________ except that *Euglena* has chlorophyll. The most plant-like flagellate group is the _______________. They have both __________ and _____________ cell walls. Many of the Dinoflagellida have a __________ cell wall like higher plants; others have no chlorophyll and ______________ their food and are called _________________. Some algae are motile (as if they were animals) and the __________________ protozoa are attached to a substate like plants!

7. Cnidospora
differentiation
polar
spore
protozoans

---

8. flagellates
chlorophyll
Cnilomonas
Khawkinea
Phytomonedida
chlorophyll
cellulose
cellulose
ingest
halozoic
Suctores

---

9. Notice how Jahn has settled the problem of classification by inventing __________ kingdoms. In Archetista he places: __________ __________.

---

10. In the __________ Monera he places: __________ __________. In our studies we have found these to be __________.

9. six
submicroscopic organisms, which live in animals, plants or bacteria.

---

11. The protozoa, green algae, red algae and brown algae are in Kingdom __________. Fungi are in Kingdom __________. Multicellular sessile, chlorophyllaceous plants are in Kingdom __________ (or __________) and the typically helozoic, motile, multicellular animals are __________.

10. Kingdom
organisms without nuclei cells solitary or physiologically independent bacteria, blue-green algae, spirochetes
PROCARYOTAE

---

12. Prepare a card on 8½" x 11" cardboard for your Field Identification Notebook. Use the description on page 8 of The Protozoa to produce a cover page. Place in this section those important protozoans not on pages 1-40. These include: Arcella discoides, Paramecium sp., Chaos carolinensis, Opalina sp. Myxobolus sp., Cryptomonas sp., Kawkinea sp., Endamoeba sp., Sphaerophyta, sp., Monocystis, Gregarina, Trichomonas sp., Nyctotherus sp., Balantidium sp., Trypanosoma sp. Labyrinthula sp., Costia sp., Kerona sp., Trichodina sp., Verticella sp., Leishmania donovani, Nosema bombyeis, Spirostomum ambiguum, Stentor coerulens.

A backup page as a key to Protozoans is given on pages 42 and 43. This should be reproduced neatly in the field notebook.

11. Protista
Fungi
Metaphyta
(Embryophyta)
Metazoa

---

13. Marine salt waters are sources of two major groups of Protozoa: __________ and __________. The Foraminifera are better dwellers even up to __________ feet. The __________ are considered to be pelagic, that is they __________. Some marine protozoans live in marine __________.

12. FIELD NOTEBOOK ASSIGNMENT

---

13. Foraminifera
Radiolaria
15,000
Radiolaria
float
metazoans

---

14. Some protozoans live in very salty places called ______________ pools; others live under geysers or in ______________ springs. Haematococcus is often found in __________ drifts. If you have completed your algae unit you may recall that member of Chlamydomonadaceas cause red snow. Other genera which cause 'bloody' snow are: _______________, ________________, ________________, _______________, and ___________________.

---

15. Some protozoans are parasitic either of animals, endozoic, or of plants, endophytic. Monocyctis is found in _______________; while ___________ is found in grasshoppers. Frogs are a laboratory source ______________, ___________ and ______________. Guinea pigs yield _____________ from intestinal material and _______________ from their blood.

14. brine
hot
snow
Scotiella
Ankistroiesmus
Raphidonema
Mycanthococcus
dinoflagellates

---

16. One flagellate genus, ______________ causes plant disease. Aquatic plants, especially eel grass, Zestera marina, have been attacked periodically by members of genus _______________________ (pg. 109). Fish skin disease is caused by _____________. Even hydra are parasitized by __________________.

15. earthworms
Gregarina
Trichomonas
Opalina
Nyetotherus
Balantidium
Trypanosoma

---

17. How big are Protozoans? Small protozoans are measured in microns. One micron is _____________ millimeter or _________ of an inch. The smallest protozoan is the causal agent for the dread disease Kala-amar, _____________ donvani; it is about ___________ microns. Some foraminifera are _________ in diameter. Mycetemoida plasmodia grow to several __________ across.

16. Phytomonas
Labyrinthula
Costia
Karena (or Trichodina)

---

18. If you have trouble estimating the size of protozoans review the unit on microscopy. Staining is best done to __________ protozoans. The _________-___________ stains like Chinese Ink and powdered carmine are very useful. Nitochondria are stained using ____________ green or janus green B. Note how Paramecia are stained and caused to emit their trichocysts (pg. 188). ___________ is useful in staining protozoans in fecal matter or sludges. Noland's solution is useful for staining ___________.

17. 1/1000
1/25000
Leishmania
1 to 4
2 inches
feet

---

18. living
intra-vitae
Janus
Lugol's solution
flagella

EM-19 PROTOZOANS
PACKET #2 (cont.)

19. Protozoans are slowed down using ______________ ______________, trade name ______________. Note that in using Methocel a ___________ is made around the organisms and they are viewed as they __________ into the more __________ fluid.	
20. Read pages 17-38 in conjunction with your reading in Sleigh. You will probably see organisms which are ________________ and certainly those which are in _______________. The drawings on these pages will help when drawing thes protozoans. Note again that the author ___________ has classified protozoans according to the Zoological Series Section of the American Association for the Advancement of Science. Family names end in _______; orders in ________________. The subphyla are determined on page 43; these are ______________, _________, _________ and ____________. DO NOT neglect to read the identification notes concerning each subphyla before attempting to identify organisms.	19. methyl cellulose Methocel ring swim viscous
	20. dividing motion T. L. Jahn -idae -ida Ciliophora Mastigophora Sarcodina Sporozoa

EM-19 PROTOZOANS
PACKET #2 END OF PACKET QUIZ

I. STRUCTURAL FEATURES: MATCHING

1. ____ plasma membrane
2. ____ endoplasmic reticulum
3. ____ nuclear envelope
4. ____ Golgi body
5. ____ mitochondria
6. ____ peroxysomes
7. ____ plastid
8. ____ contractile vacuole
9. ____ lysosome
10. ____ stigma

A. dictyosome

B. respiratory particle rich in oxidase enzymes

C. where diastolisis and systolisis occur; near plasma membrane

D. main organelle of energy transformation

E. organelles rich in hydrolytic enzymes

F. connected to the endoplasmic reticulum; ribosomes on outer cytoplasmic surface

G. unit membrane layer; controls concentration of substances within the cell

H. photosynthetic organelles of autotrophic flagellates

I. red-pigmented portion of phtotaxis controls

J. a system of membranes separately off closed channels or vesicles whose interior is not in continuity with the cytoplasm

II. STAINING PROTOZOANS:

Describe how you could capture protozoans from any environment, concentrate them and then separate them into colonies ----- ALIVE.

How would you study them alive?

How would you study them by stains?

How would you study their feeding habits?

How would you judge their size?

EM-19 PROTOZOANS

PACKET #2 END OF PACKET QUIZ (cont.)

How do ciliates and flagellates differ in reproductive division?

III. LOCOMOTION:

How can the observer diffentiate between locomotion by cilia, flagella and pseudopodia?

IV. CLASSIFICATION:

What are the four subphyla shown in Jahn's?

V. FILL IN THE SUBPHYLA TO MATCH THE CLASSES.

CLASS	SUBPHYLA
CILIATEA	________
ACNIDOSPORIDEA	________
ZOOMASTIGOPHORA	________
SUCTOREA	________
PHYTOMASTIGOPHORA	________
RHIZOPODEA	________
TELOSPORIDEA	________
CNIDOSPORIDEA	________

Environmentally protozoans are found in soil, sludge, waste streams and in composts. Most protozoans are saprele, but some grow within other plants and animals. In any decaying organic materials they can be expected. Flagellates, rhizopeds and ciliates feed mainly upon bacteria, their favorite food, but on occasion they feed upon fungal spores, hyphae, algae, slime molds, actinomycete spores and rotifers. Some feed saprophytically on organic debris and most utilized dissolved organic compounds. In other units the taxonomy and identification of these important creatures are studied; here their collection and examination is considered.

Although it is possible to capture feeding protozoans by the buried slide technique the easiest way to capture them is to coax them into feeding upon bacteria which the microscopist has placed "in the open" for them. Much study has gone into determining just what most bacteria like (Singh, 1941, 1945). These studies have revealed that just like humans protozoans have their favorite foods and some major dislikes. Some bacteria and other microorganisms either excrete or contain within their cytoplasm biochemicals which protozoans find "distasteful"; they avoid such microbes. Singh found that Enterobacter aerogenes is an excellent food and devised a method to capture them for study and also to count them in a given sample. Basically his method involves growing E. aerogenes on a non-nutritive agar (Nobel agar). The bacteria spreads over the surface living on what little nutrients are in the liquid used in its initial dispersal and growth of other microbes from the sample is discouraged. Protozoans in the introduced sample feed voraciously on the soft plump bacteria "cleaning the agar" so that their presence is revealed. When Singh's method is used with a dilution series a most-probable-number count or an extinction-dilution count is possible. See the packet concerned with dilution series.

METHODS AND MATERIALS:

MATERIALS:

1. Singh's agar for protozoa:

Use a prewashed commercial agar such as Noble agar or wash ordinary agar for three to five days in repeated washings with distilled deionized water. Prepare 1.5% Nobel agar in 0.5% NaCl solution (m/v); adjust pH usin g Hydrion paper or the pH meter to 6.5 to 7.0 pH. Sterilize the agar-NaCl solution by autoclaving at 15 psi, for twenty minutes. Cool to about 45C (baby bottle test) and pour into the requisite number of Petri dishes to about 4-5 mm deep. Place three to five flamed (or autoclaved) glass rings in the dish set so as not to touch, to provide small protozoan "corrals".

2. Sacrificed Bacteria:

Prepare a thick suspension of Enterobacter aerogenes by inoculating the bacteria onto solidified nutrient agar contained in petri dishes. Incubate at 37°C for two to five days ; then add 2-3 ml of sterile 0.5% NaCl solution. Use a

---

sterile pipette or transfer loop to bring the bacterial growth into suspension.

3. Set the trap:

Spread a thick suspension of the innocent bacteria on the agar surface within each ring. Make the suspension thick enough to be opaque. Set aside until you have your unknown sample ready.

4. If an extinction-dilution count is to be made prepare a dilution series of 9.5% NaCl solution using 100 ml bottles filled with 90 ml of salt solution. Prepare one bottle (the first in the series) with 90-95 ml* of salt solution and 8 to 9 glass beads. (*If the material to be tested is "soil-like" use 95 ml; if humus or bark use 90 ml; if watery use 90 ml). Place 10 grams (or 10 ml) of sample in the first sterile dilution bottle. Shake until beads have broken up the organic substrate (five minutes). Remember if you are doing quantitative work to remove an aliquet of your sample for moisture determination.

5. If you are going to separate active from cystic protozoa prepare a 2% HCl solution (100 ml).

METHOD (PROCEDURE);

1. Transfer 0.05 ml of inoculant to each bacterial patch using a sterile 1 ml graduated pipette.

2. Incubate at room temperature (37^{o}C for enteric pathogens) for two weeks without inverting the plates.

3. If plates appear to be drying add a drop of aqueous 0.5% NaCl to the circles.

4. Remember to save one plate of uninoculated bacteria as a blank to which to compare those which show growth.

5. Assign positive growth (+) to those which show erosion, alteration or "moth-eaten" look.

6. Examine the rings under low power of the binocular microscope. DO NOT USE HIGH POWER AND IMMERSE THE LENSES IN THE MUSH!!!!

7. You are encouraged to make wet mounts, hanging drop slides, and stained dry mounts for examination under the microscope.

---

8. To secure separate estimates of active and cystic protozoa first count the total protozoa by the extinction-dilution technique. At the time of withdrawing a sub-sample for the total protozoan count, withdraw a duplicate 10-g sample; and treat it overnight with 40-50 ml of 2% HCl. For calcareous soils, make certain that sufficient HCl remains to ensure an acidity of approximately pH 1 during the overnight exposure period. After 12 to 24 hours, decant the supernatant fluid, and add 0.5% NaCl to bring the remainder to a total volume of 100 ml. Shake the mixture for five minutes; then make a dilution count according to the ring method. The results represent a cyst count. (The active forms are killed off by the acid solution.). Obtain the active count by subtracting the cyst count from the total count.

ASSIGNMENT: Read the selected readings for this module on PROTOZOANS. Be sure to add Enterobacter aerogenes and other microbes you have seen or read about to your Field Identification Notebook.

EM-19 THE PROTOZOANS

PACKET #5 PROGRAMMED REVIEW ON SINGH'S ARTICLES ON SOIL AMOEBAE

1. In 1916 Oehler suggested (incorrectly) that amoebae prefer G-__________ to G-__________ bacteria as food. He also found that some protozoans can eat dead __________, while others are strictly __________. Severtzova in 1928 studied the bacteria, acinomycetes, __________, and __________ and found that __________ were preferred food for protozoans. Cutler and Crump in 1927-35 used Hartmanella hyalina and found that the bacterial food varied in __________ value.	
2. How did Singh obtain a 'pure' protozoan strain? __________	1. negative positive bacteria parasitic fungi yeasts small motile non-sporing bacteria and immotile cocci nutritional
3. What device is utilized to study the amoebas food preferences? __________	2. transferred, over and over again, amoebae which escaped Singh rings
4. What happens when the bacterial food is liked? disliked? __________	3. bacterial 'stars' made from thin tubes filled with bacteria in nutrient media.
5a. How was the theory of exotoxins tested? This requires some notes. (b) How were endotoxins tested? __________	4. the amoebae feed and multiply before moving on. the amoebae either encyst or move on and give up and encyst
	5a. by growing nonedible forms, scraping them off, and inoculating agar made from the old agar with edible forms and retesting. b. Crushed cells were tested in a similar manner (IF STILL CONFUSED CONSULT WITH INSTRUCTOR)

---

6. It may be concluded that given a choice amoebas do have definite ____________ in food, but that they have a wide ____________ of feeding habits. They do on occasion eat __________, ____________, ______________ and _____________ spores.

---

7. Amoebae and flagellates lead a mainly _______________ existence controlling the levels of bacteria.

6. preferences
range
yeasts, algae, bacteria
fungal

---

8. Species 2881, a rod shaped dark colored bacterium did produce an _________________. It was on occasion however. Results __________ conclusive.

7. holozic (predatory on bacteria)

---

9. Protozoans __________ affect levels of bacteria in soils.

8. exotoxin
were not

---

10. Spore producing _____________ __________ withstand the predation of protozoans better than coccobacillus and coccus forms.

9. DO

---

11. What did Singh set out to prove or show in his pigment experiments? ____________________
____
____.

10. bacilli
do

---

12. From what main sources did Singh obtain his test bacteria? _____________________________
____

11. that bacterial pigments either do or do not act to spare them from predacious protozoans

---

13. Where do we get our cultures?

12. National Collection or Type Cultures or other researchers

---

13. same place. Experiments must be accomplished with known species

---

14.What substances were extracted from Pseudomonas pyocyanea?	
15. Which is most toxic to protozoans; crude pyocyanin or pure pyocyanin? What effects does the 'impurity' of pyocyanin have?	14. pyocyanin -hydroxyphenzine two unknown antibiotics and a fluorescent toxicant
16. What substance was found in the agar surrounding Chromobacterium prodigiosum?	15. crude pyocyanin is toxic and affective if not destroyed by heat. The impurity is toxic also even if autoclaved NOTE: This is a typical fact not utilized yet to find a new antibiotic
17. What happened with Chr. Volacerum?	16. an insoluble exotoxin which gradually killed most protozoans that were found. The endo-pigment was not very effective.
18. A. What effect did penicillin have against protozoans? B. What about penicillic acid & citricin?	17. The protozoans were slowed, couldn't always reproduce, some rounded and burst!
19. What important principal is shown in the DISCUSSION?	18. A. None B. in combination some effect at high concentrations note interaction of drugs.
	19. Protozoans like other creatures are individuals. They are complex. Their existence is an ecosystem requires knowledge of the WHOLE ENVIRONMENT.

20. What protozoans belong in your F.I.D. notebook? What other microbes? ______________	
	20. Flabellula mira (like F. velata in Jahn & F. citata in Sleigh; record all these on same page.) *Pseudomonas fluorescens (Note Bergey, p 217-43, esp. 222.)* *Chromobacterium violaceum (Note Chr. prodigiosum & Chr. viscosum are no longer recognized in Bergey's)* *Micrococcus roseus (pgs. 478-90-Bergey's (Family), pg. 481 for M. roseus, student already has utilized M. luteus (Sarcina lutea) in most cases.* *Carcomonas crassicanda (pg. 84 - Jahn's; 274 Sleigh)* *Colpoda cucullus (pg. 193-Jahn's; 196, 197, 261, 266, 274 in Sleigh)*

THERE IS NO QUIZ FOR THIS PACKET. SUBMIT KRITTER SHEETS TO INSTRUCTOR.

EM-19 PROTOZOANS
END OF MODULE TEST

TECHNICAL TERMS: MATCHING

1. ____ adoral zone	A. a pseudopodium of fingerlike (blunt) character
2. ____ axenic	B. cultures containing only a single species of organisms
3. ____ cirrus	C. cell anus
4. ____ coenobium	D. an envelope or covering fitting the protozoan loosely
5. ____ lobopodium	E. reproduction by multiple fission
6. ____ trichocyst	F. the specialized area of membranelles leading to the cytostome in ciliates
7. ____ cytopyge	G. an organelle resulting from the fusion of tuft of cilia, used chiefly for locomotion; characteristic of spirotrich ciliates
8. ____ schizogony	H. living in the cavities of the host
9. ____ lorica	I. an organelle underlying the surface of many ciliates and some flagellates capable of sudden discharge
10. ____ coelozoic	J. a colony of flagellates (e.g. (Volvox)

CLASSIFICATION (JAHN & JAHN)

Within Kingdom 2, PROTISTA: Phylum 1 is PROTOZOA. It is composed or divided by these authors into four subphyla. Name them:

1.
2.
3.
4.

DEFINE THE FOLLOWING DESCRIPTIVE TERMS:

pyrenoid =

clone =

sporocyst =

stigma =

trophozoite =

plasmalemma =

---

peduncle =

mastigont =

opisthe =

cytopharynx =

SYNONYMS MATCHING:

1. ____ girdle	A. mutinucleate
2. ____ shell	B. endoplasm
3. ____ polyenergid	C. cingulus
4. ____ moniliform	D. gregarine
5. ____ inquiline	E. kinetosome
6. ____ endosarc	F. autotrophic
7. ____ basal granule	G. beadlike
8. ____ acephaline	H. ectosarc
9. ____ cortex	I. test
10.____ holophytic	J. commensal

DESCRIBE THE PHYTO - V.S. ZOO - MASTIGOPHORA TAXONOMIC PROBLEM

CILIA AND FLAGELLA MATCHING

1. ____ axoneme	A. cilial basal body
2. ____ cilia	B. thick lateral hairs on flagella
3. ____ blepharoplast	C. longitudinal bundle of microtubular fibers
4. ____ kinetosome	D. flagellar basal body
5. ____ tubulin	E. fibril submit globular protein (factin or spactin)
6. ____ dynein	F. similar to flagellum but different in internal structure
7. ____ haptonema	G. pattern of metachronal coordination
8. ____ mastigoneme	H. compound non-locomotive organ of several cilia
9. ____ sympletic	I. arms on peripheral doublets
10.____ cirri	J. specialized form of flagella

EM - 20 ADVANCED LABORATORY TECHNIQUES

PURPOSE: To introduce the student to those chemical, physical and microbiological methods which are available at major universities and reaearch centers. For the most part the instruments, materials and physical plant required for these methods are exceedingly expensive and hands-on experience is not possible. Filmstrips, casettes and estensive reading are possible. In some cases arrangement will be made for off-campus, hands-on experience on equipment where possible.

MATERIALS:

1. Communication Skills Corporation Slide - Tape Presentations, P. O. Box 684, Fairfield, Conn. 06430.

#1001 - INFRA-RED SPECTROSCOPY
#2001 - BASIC GAS CHROMATOGRAPHY
#3001 - ATOMIC ABSORPTION SPECTROSCOPY
#4001 - BASIC LIQUID CHROMATOGRAPHY
#5001 - MASS SPECTROSCOPY
#6001 - BASIC NUCLEAR MAGNETIC RESONANCE PHENOMENON

2. W. B. Saunders Co. Unit - ELECTRON MICROSCOPY: PRINCIPLES AND PRACTICES.

3. Microscope

REFERENCES

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8. Felton, C. D. and Greider, M. H. Electron Microscopy. Chem. Annv. Rev. 38:209-250.

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11. Idle, D.B. Preparation of Plant Materials for Scanning Electron Microscopy. J. Microsc. 93:77-79.

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13. Kimoto, S. and Russ, J. C. The Characteristics and Applications of the Scanning Electron Microscope. Amer. Sci. 57:112-133.

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17. Scott, R. and Weissberger, A. Contemporary Liquid Chromatography. Wiley-Interscience.

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19. Steere, R. L. Freeze-etching Simplified. Cryobiology 5:305-323.

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OBJECTIVES: To enable the student to:

1. Understand the principles upon which are based the analytical procedures used in environmental studies today.

DATE STARTED: ____________________

EM-20 ADVANCED LABORATORY TECHNIQUES   INSTRUCTION AND CHECK OFF SHEET

This unit is designed for the student in Natural Resources Management who has progressed successfully through all of the chemistry modules, It is a challenging unit, but one worthwhile especially for those entering water and wastewater technology.

NOTE: Texts and journal articles are still being reviewed for inclusion in the packets of this module. Further, the division of this module into several modules is considered. Packets on thin layer chromatography, phase microscopy, use of fluorescence technique and other advanced techniques have not been included. This module is not complete, but will serve to show the direction for completion of several modules on advanced analytical techniques.

PACKET #1 - Read Reynold's paperback, PRINCIPLES OF ANALYTICAL CHEMISTRY. Ask questions of the instructor when necessary....You will refer back to this booklet throughout the other packets.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #2 - CSC #1001 - INFRA-RED SPECTROSCOPY
Utilize the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #3 - CSC #2001 - BASIC GAS CHROMATOGRPAHY
Utilize the the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #4 - CSC #2001 - ATOMIC ABSORPTION SPECTROSCOPY
Utilize the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #5 - CSC #4001 - BASIC LIQUID CHROMATOGRAPHY
Utilize the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #6 - CSC #5001 - MASS SPECTROSCOPY
Utilize the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

PACKET #7 - CSC #6001 - BASIC NUCLEAR MAGNETIC RESONANCE PHENOMENON
Utilize the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ____________________

EM-20 ADVANCED LABORATORY TECHNIQUES INSTRUCTION AND CHECK OFF SHEET (cont.)

PACKET #8 - ELECTRON MICROSCOPY - PRINCIPLES AND PRACTICES
Utilize the tape and slides making up technique sheets as you go along.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

TAKE END OF MODULE TEST.

DATE COMPLETED: ____________________
INSTRUCTOR SIGNATURE: ______________

EM-20 ADVANCED LABORATORY TECHNIQUES
END OF MODULE TEST

FOR EACH OF THE TECHNIQUES LISTED EXPLAIN WHERE IT IS MOST USEFUL, ITS STRONG POINTS AND WEAK POINTS AND DISCUSS THE MANPOWER AND EQUIPMENT COSTS. EACH EXPLANATION SHOULD BE AT LEAST ONE TYPEWRITTEN PAGE LONG. WHEN COMPLETED HAND INTO INSTRUCTOR AND DISCUSS.

1. GRAVIMETRIC ANALYSIS
2. TITRIMETRIC METHODS
3. GASOMETRIC METHODS
4. ABSORPTIMETRY
5. EMISSION SPECTROSCOPY
6. NEPHELOMETRY
7. REFRACTOMETRY
8. POLARIMETRY
9. POTENTIOMETRY
10. CONDUCTIMETRY
11. POLAROGRAPHY
12. COULOMETRY
13. MASS SPECTROSCOPY
14. GAS CHROMATOGRAPHY
15. LIQUID CHROMATOGRAPHY
16. TLC or PAPER CHROMATOGRAPHY
17. NUCLEAR MAGNETIC RESONANCE TECHNIQUES
18. ELECTRON MICROSCOPY
19. PHASE MICROSCOPY
20. ATOMIC ABSORPTION